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Paper Title: Broadening the space for low carbon transition: addressing consumption and production in low carbon futures

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Conference track: 1. Whole system reconfiguration across production and consumption

Abstract

It will be difficult to achieve a rapid low carbon transition in the UK without significant changes in how we make and consume materials and products, but we have a poor understanding of what these changes might be and what they mean for the UK economy and society. The current approach to understanding low carbon transition tends to focus on developing technological scenarios of energy system change and the public acceptability of these technologies. This overlooks the significant opportunity presented by making things differently or by consuming things differently. Broadening the perspective of low carbon transitions in this way requires a new way of scenario development that is able to take into account qualitative, socio-technical aspects of transition, as well as quantitative modelling. We present an approach which combines narrative storylines and economic modelling to capture the dynamics of transition more effectively. This approach also enable analysis of whole system reconfiguration of sustainable consumption and production, not just decarbonisation of the energy system. Our result show… We find that….

1 Introduction

It will be difficult to achieve the scale and speed of transition necessary to avoid dangerous climate change without making changes to consumption and production. However, there is a great deal of uncertainty about what these changes might be and how they might affect the economy and society. There is a great deal of work exploring different scenarios and pathways that might achieve country-level CO2 targets (for example Babonneau et al., 2018; Deetman et al., 2013; Ekins et al., 2011; Foxon, 2013; Li and Strachan, 2016), however, the majority of these scenarios focus on the energy system or are based on energy system models. In parallel several scenarios have been developed to explore sustainable lifestyles (Neuvonen et al., 2014; Schanes et al., 2016)

This overlooks the significant opportunity presented by making things differently (e.g. using less material and therefore producing less carbon during its production) or by consuming things differently (e.g. by sharing, rather than owning, a car meaning that fewer cars are needed and less carbon is produced to manufacture the necessary stock of cars) (Allwood et al., 2011; Barrett and Scott, 2012; Scott et al., 2017).

In order to realise substantial reductions in emissions it is crucial to look beyond the energy system and seek additional opportunities for emissions reduction. In this paper we aim to broaden the scope of low carbon transition scenarios by considering whole system reconfiguration that includes changes to consumption and production, as well as the energy system.

2 Scenario techniques

Scenarios are widely used to support decision making in the face of uncertainty, particularly where planning horizons are long-term. There has been a proliferation of studies employing scenarios in both the academic and policy sphere to examine low carbon transitions. The wide variety of contexts in which scenarios have been developed has led to wide variety of approaches and methodologies for constructing scenarios and for the different ways they are used. Previous reviews of low carbon scenarios has identified a common distinction between normative scenarios, which focus on identifying pathways to desirable futures and exploratory scenarios which do not predetermine the end-point for the scenario [ref McDowall and Eames 2006]. The distinction between these two approaches is seldom clear and there tends to be a sliding scale with some scenarios with very prescriptive normative constraints and others controlling only some elements.

2.1 Trend-based studies

2.2 Technical feasibility studies

2.3 Modelling studies

3 Approach to developing scenarios

In seeking to develop scenarios for low carbon production and consumption in the UK, we are strongly driven by two key desires from policy makers and wider stakeholders: for identification of additional opportunities to meet increasingly challenging carbon budgets; and for plausible but transformative narratives of industrial futures to support decision making in relation to industrial strategy. By considering these goals together we aim to identify how UK industry can evolve in a climate compatible way but also how it can contribute more broadly to climate change mitigation.

However, we recognise that industrial futures and mitigation opportunities are closely linked to changes in consumption patterns and in wider societal and economic trends. This requires an approach that goes beyond traditional sector technology roadmaps or energy scenarios that are limited to exploring direction of travel based on projected technology deployment and possible future interventions. Despite its useful insights, such work does not illuminate how such technological change in production and energy generation and use would affect, or indeed be driven by changes in consumption patterns, society or the economy. These interlinkages must be addressed to fully understand the implications of any transition and also to identify additional drivers and intervention points to support transition.

3.1 Narrative development

Our approach is based on identifying key trends driving change in the current system and extending individual trends to create contrasting narratives. In reality, these trends will all evolve in some way at the same time but our narratives isolate one trend and take it to the extreme, assuming that the majority of change stems from just one type of change. This helps us to describe how they are routed in reality but also to show some of the more extreme implications of following just one path.

Four key trends were identified from a review of existing scenarios and an expert workshop held in September 2016. These trends were:

- Societal change, including consciously reducing consumption and finding alternative means of satisfying needs;

- Technological change, increasing the efficiency of technology in producing or doing the same things;
- Market-driven change, which arises in response to price signals and competition;
- Collaboration, including the sharing economy and service-oriented business models.

Initial narratives were drafted to reflect the evolution of these trends and reflect how they would influence production processes, consumption patterns, infrastructure and governance. The narratives were given a title that aimed to reflect the nature of the change it represented:

- 'Decluttering' reflected social change
- 'Industry 4.0' reflected technological change
- 'Market-fix' reflected reliance on markets to drive change
- 'Collaboration' reflected the rise in the sharing economy and collaborative business models

It should be noted that these narratives are simplifications and static representations of a system that is always in flux. Elements of one can be co-opted or co-exist with another, but each usually has a dominant and influential organising principle. These scenarios are, then, not exclusive but illustrative of different principal narratives. However, the internal consistency of each narrative and the difference between narratives was reviewed and is summarised in table 1 below.

Table 1: Summary of narrative characteristics

	Collaboration	**Industry 4.0**	**Market fix**	**Decluttering**
Role of government	Government procurement as a driver and a leader. Enabling innovation and collaboration.	Explicit and active industrial strategy. Lots of engagement. Regulation to drive innovation.	Building commitment and security and clear messages for industry.	Central government is much weaker, governance is more grassroots.
Social Justice	Central to scenario	Real distributional effects	Potential for significant distributional effects	Central to scenario
Conviviality/meeting human needs	Central to scenario	Assumes that needs can be met through technology	Assumes that needs can be met through markets	Wellbeing becomes central indicator of development
Visibility/ encroachment	Low encroachment but highly visible	Heavy automation & encroachment but 'behind the scenes'	No encroachment	Low encroachment – grassroots action
Innovation	Innovation in business models	Innovation in products	Innovation only where it reduces cost	Grassroots innovation and innovation in demand
Role of 'smart'	Enabling collaborations	Smart in industry for efficiency	Smart in industry for efficiency	Unclear

The initial version of the narratives were iteratively refined through workshops in April and October 2017. The first workshop presented the narratives and asked for specific feedback on content from a

mix of academics and advocacy organisations. The second workshop included representatives from the Committee on Climate Change, the ETI, WRAP, Green Alliance, and Accenture. At this workshop, the revised narratives were presented and feedback was provided about the consistency, the framing and the content of the narratives.

3.2 Quantification of narratives

Quantification on the narratives used a UK Econometric model: the MAcroeconometic Resource COnsumption model (MARCO). The model constructs econometric relationships between 50 key socio-technical-economic variables including GDP, employment, savings, wages, energy use and energy efficiency. As a result it can be used to test the impact of future scenarios (such as energy demand caps, austerity measures) on the UK energy-economy.

Quantification of the narratives involved specifying the changes that would occur to model variables, which was undertaken in a workshop with the narrative developer and econometric modellers. Evidence was gathered to support the scale of change identified. An example of such evidence is presented in Appendix X. Variables were changed as much as was consistent with supporting evidence of what could be achieved within the context of the scenario narrative, with the aim of achieving an 80% reduction in CO2 emissions. However, this target was not forced to allow us to explore the limitations of individual narratives in reaching stringent mitigation targets.

One of the limitations of the modelling was that it is not currently possible to show the resource implications of the scenarios, this was limited to measurement of energy and carbon and economic and social outputs. Another limitation was the lack of sectoral detail and our ability to identify sector-specific insights; the MARCO model included only 'energy' and 'non-energy' goods.

4 Results

4.1 Scenario narratives

4.1.1 Decluttering

A decluttering scenario presents possibly the greatest departure from familiar lifestyles. In this scenario there is negative orthodox economic growth and significant social change. If you were to think of this as a city, you might imagine places that have had to innovate and respond after experiencing systemic economic failures or other shocks, such as Buenos Aires, Athens, or Havana at the end of the cold war.

There is a focus on massive expansion in public transport and measures to reduce car ownership, shifting infrastructure to make car use less convenient. Individual car ownership becomes a rarity, and car free cities the norm. 'Staycationing' becomes the norm, and flights are only taken for essential purposes.

'Choice editing' occurs as popular amenity ranges emerge across a range of goods, but are designed in such a way as to allow for personalisation. Conspicuous consumption of resource intensive new goods is heavily taxed. But a thriving second hand, remake and reuse culture allows for novelty in goods for those who seek it.

Education shifts towards skills needed for active citizenship, communal and individual well-being. In health policy there is a major shift towards public health. Immigration is more tightly controlled alongside a broad programme of 'solidarity twinning' between UK communities and communities in the Global South, and other low income countries. Various policies are used to encourage a maximum of two children per family.

International trade, except for essentials, is rare. The state is smaller with much authority devolved to regions. Local and regional identities assert themselves more. Cities become a greater focus for organisation and decision making. Community life experiences significant revival. New forms of associational support proliferate for families, individuals and communities.

Central government is weaker and governance is much more grassroots. However, there would need to be government intervention on basic incomes, shorter working weeks and new measures of prosperity.

4.1.2 Industry 4.0

In the Industry 4.0 scenario there is no expectation that behaviour will have to change fundamentally to achieve low-carbon energy targets. Everything is done to use technology to make the process of transition as invisible as possible. There is an expectation that more general consumption patterns do not change and that a continuity of lifestyle is possible. If you were to compare it with life in a foreign city, you might imagine somewhere like Singapore.

In this scenario private car use is unmanaged but modified by the latest innovations such as electrification and driverless vehicles. Urban centres are compact and pedestrianised, but also have clean, efficient, electrified mass transit systems. There is a large concentration of renewable power and/or nuclear, with carbon capture and storage wherever fossil fuels are still used. A major focus on energy efficiency is linked to a comprehensive programme of retrofit and renovation of the built environment.

Subsidies are shifted from production and consumption to research, development and innovation. Tax incentives, infrastructure and banking policy and state-backed investment institutions encourage small and innovative enterprises in the sustainability sector.

Highly active social media accelerates uptake of new innovations. Smart and information technologies underpin a wave of automation that changes the face of industry and the service economy. A higher level of structural unemployment is only partly offset by new service sector opportunities where the very dominance of technology has created a new high-end market for personal services.

The economy is globally integrated but there is less emphasis on the export of goods and more on ‘ideas’; this economy is as likely to sell patents as goods. Manufacturing is geared toward high-value technological products and there is little interest in extractive industries and primary materials. But, the tech sector is heavily dependent on importing specialist primary products such as rare earth materials.

Circular economy approaches with modular production are core. But, the expectation of technology being able to maintain unchanged lifestyles at a lower material level, means significant behaviour change is harder to achieve and there could be implications of economic rebounds. The government is an interventionist, not hands-off state, with a clear, strong industrial policy geared toward picking winning sectors. Regulation, particularly material and product standards, will be used to drive innovation in production processes.

4.1.3 Market fix

In the market fix scenario, the core belief is in the ability of market forces to solve problems. Day-to-day life is fully recognisable with little change visible from today’s economy. For the market fix to work, price mechanisms are relied upon to change production and consumption.

No limits are placed on consumption, but there is a shift to include the full environmental costs of production and consumption in the price of goods. Beyond that, however, the market and society are largely left to their own devices. If you were to think of this as a city, you might imagine somewhere like Boston or Silicon Valley in the San Francisco Bay area.

A carbon floor price and other specific policies such as the frequent flier levy push up the cost of carbon intensive activities. Train travel across Europe becomes more popular and relatively affordable. Private car use is still common. Offsetting schemes are offered to individuals and are common in the shipping and aviation sectors but otherwise they largely escape climate-based regulation.

Progressive metering tariffs become standard for energy use, but here the benefits are mostly reaped by those who can afford to retrofit and renovate their homes and workplaces. There is a fundamental tension between setting an effective carbon price and the social and political impact of poverty. Basic welfare provision is made.

Emissions trading at different levels, geographically and sectorally, is a key device to reduce emissions. Innovation in industry occurs only if it offers a cost saving (or sufficient carbon savings to reflect carbon price-adjusted cost savings). This is supported by smart technologies that can support efficiency in production.

There is less regulation in this economy in terms of protection given to social and environmental concerns, with the belief that the right kind of business 'enabling' legislation will free the market to find solutions regardless. The economy is fully globally integrated with a strong emphasis on international trade and finance. The orthodox market approach sees lower levels of innovation than in the industry 4.0 scenario.

The government is not hands-off in this scenario, but the key intervention is price adjustment. The government has an important role in building commitment and security and sending clear messages to industry, and encouraging long-term investment.

4.1.4 Collaboration

In this scenario, the role of sharing is emphasized and there is a shift from selling products to selling services. There is a key role for business model innovation to support these new forms of consumption and production. If you were to compare this narrative to life in a foreign city you might imagine Stockholm. Working patterns are different with a greater work/life balance. There is state provision of childcare and more flexible workplaces. There is increased public transport and cycling with less private vehicle use. Leasing rather than outside ownership is the norm. There is active urban planning and car-free towns and cities. People fly less and take more holidays at home or in destinations easily reached by public transport.

Various forms of ecological taxation are taken for granted, as is the low-carbon agenda, but as well as financial encouragements to shift production and consumption patterns there is a strong emphasis on social policy innovation. Advertising, for example, is subject to greater controls in public places and children and young people in particular are protected from consumer pressures. The housing market is less distorted by speculation, and there is a higher proportion of social, cooperative and community ownership. The economy is more regulated to address market failures, and also to encourage innovation among micro and small businesses and community and social enterprises.

Social enterprises, cooperatives, community interest companies and mutual are more common. The

success of enterprises is judged against a wide range of indicators such as social and environmental policy outcomes. Electrification and smart grids are the order of the day, with comprehensive support for efficiency and measures for demand management to both tackle peak demand and lower demand more broadly. Energy companies are subject to a demand reduction obligation.

In industry and manufacturing there is movement towards the circular economy with a focus on selling services, rather than selling things. Minimum product lifespans backed by repair/return warranties are longer, modular manufacturing common, and reparability is a selling point of consumer goods. The "Library of Things" approach and the real sharing economy is enabled at the local level with effective, digital trust-based platforms. There are versions of Uber and AirBnB but these are more regulated to prevent a 'race to the bottom.' There is an onus on demonstrating innovation and efficiency above normal background rates and industries are expected to work with their supply chains to deliver this. Innovation is focussed on business models and product longevity. Collaborative business models are enabled by smart technology.

As a whole the economy is less dependent on international trade and industrial policy is geared toward increasing indigenous manufacturing. Apprenticeships are typically available and basic levels of practical skills for product maintenance and repair are inculcated in the population from school age. The government's role in this scenario is to incentivise and enable collaboration and business model innovation. This 'innovative governance' will promote networks and facilitate business models that enable collaboration or service-oriented business models. It will also use public procurement as a driver.

5 Discussion

- If we consider materials and products we get additional ways to address the increasingly challenging gap between energy system carbonisation and carbon budgets;
- There are many ways we could address the energy use and emissions associated with material and products that have differing implications for the economy and society;
- Addressing energy use in materials and products will also address some other rather pressing issues you have around resource use.

This highlighted a slight challenge that we were conflating society-wide trends and policy approaches (i.e. in the market forces scenario we are assuming that business responds more to market forces and that the majority of policy is market oriented). This is a bit tricky because they are really separate things so we need to be very clear in explaining how this has influenced our modelling

The integration of energy and the wider economy was seen as a real point of novelty in both the scenarios and the modelling more broadly and really helped the attendees to see how we were addressing the points in the first comment. I think we need to make the most of this when describing the scope of the scenarios and the insights we gain from this analysis. The model as I described it gave far more detail on the wider interactions with the economy and granularity of indicators that stakeholders are interested in (e.g. labour productivity, not just jobs; interaction between capital energy and labour, not each in isolation).

One driver identified was that these scenarios can allow governments and businesses to become less exposed to risk and volatility – this may be a motivational point in communication to an audience. Is it possible that we can quantify/allocate risk in these scenarios?

6 Conclusions