Large scale energy storage

CryoHub

Developing Cryogenic Energy Storage at Refrigerated Warehouses as an Interactive Hub to Integrate Renewable Energy in Industrial Food Refrigeration and to Enhance Power Grid Sustainability

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1. Executive summary

The CryoHub project is designed to maximise cryogenic energy storage efficiency by recovering energy from cooling and heating in a perfect renewable energy source-driven cycle of cryogen liquefaction, storage, distribution and efficient use. This work package recognises that contextual factors form the basis of the technical regimes in which we operate and which we seek to change. The work package draws on previous work with the cold storage industry, which has demonstrated the important influence that contextual issues such as individual and organisational attitudes and behaviours, as well as cultural and market conditions, can have on the adoption of low carbon technologies and energy efficient practices.

This literature review examines a number of theories, models, frameworks and relevant previous research associated with energy use and the drive towards carbon reduction and increased use of renewable energy. It considers theories associated with change at the level of the individual, the organisation and the wider system. The following key points are especially relevant to this project.

- *Change at the level of the individual*

Behaviour change theory, such as theories of interpersonal behaviour, behavioural economics theories and the UK Government's pro-environmental behaviour frameworks all emanate from social psychology and economic traditions and it is these theories and models that have dominated the popular policy discourse to date.
In social practice theory, the individual is no longer taken as the unit of inquiry. Instead the focus is moved to the actions (or practices) themselves. So, for example, rather than trying to influence decisions made by individuals social practice theory looks at the energy consuming actions themselves and the context around them. Both approaches view the same issue from diverse perspectives however it is suggested that it is perhaps at the intersections between these theoretical approaches that the most novel and important policy intervention implications are likely to be found.

The traditionally more individualistic approaches of social psychology can benefit from engagement with the more social models of social practice theory in which individual practices are inseparable from the material, procedural, and social structures that constitute them and the other practices to which they connect. Conversely a deeper and more wide-ranging engagement with the diverse theoretical, empirical, and epistemological approaches that constitute contemporary social psychological theory might offer similarly useful 'borrowings' for both the theorising and changing of the social meanings of practices.

- *Organisational change*

Complementarities theory examines the interplay between personal, skills related, cultural and sector-wide influences in an organisational change context. The theory shows how change is created when 'doing more of one thing increases the returns of doing more of another' or investing in one variable makes it more profitable investing in another, setting off a potentially virtuous circle of change. Embracing within it a range of other theories and models including cultural theory, organisational responsiveness levels and socio-technical regimes, complementarities theory uses a matrix model of interconnected 'quadrants' that can be used with individual organisations to reveal, map and work with their barriers and enablers to change. The tool has already been usefully applied in a cold chain context to determine the barriers and enablers to the diffusion of energy efficient technologies in European cold stores.

2. Context

2.1. Cryohub overview

The CryoHub innovation project will investigate and extend the potential of large-scale Cryogenic Energy Storage (CES) and will apply the stored energy for both cooling and energy generation. By employing Renewable Energy Sources (RES) to liquefy and store cryogens, CryoHub will balance the power grid, while meeting the cooling demand of a refrigerated food warehouse and recovering the waste heat from its equipment and components.
The intermittent supply is a major obstacle to the RES power market. In reality, RES are fickle forces, prone to over-producing when demand is low and failing to meet requirements when demand peaks. Europe is about to generate 20% of its required energy from RES by 2020, so that the proper RES integration poses continent-wide challenges.
The CES, and particularly the Liquid Air Energy Storage (LAES), is a promising technology enabling on-site storage of RES energy during periods of high generation and its use at peak grid demand. Thus, CES acts as Grid Energy Storage (GES), where cryogen is boiled to drive a turbine and to restore electricity to the grid. To date, CES applications have been rather limited by the poor round trip efficiency (ratio between energies spent for and retrieved from energy storage) due to unrecovered energy losses.
The CryoHub project is therefore designed to maximise the CES efficiency by recovering energy from cooling and heating in a perfect RES-driven cycle of cryogen liquefaction, storage, distribution and efficient use. Refrigerated warehouses for chilled and frozen food commodities are large electricity consumers, possess powerful installed capacities for cooling and heating and waste substantial amounts of heat. Such facilities provide the ideal industrial environment to advance and demonstrate the LAES benefits.
CryoHub will thus resolve most of the above-mentioned problems at one go, thereby paving the way for broader market prospects for CES-based technologies across Europe.

2.2. Overview of Work Package 8 – Market barriers and strategies

Contextual factors form the basis of the regimes in which we operate and which we seek to change. These fundamentally non-technical aspects need to be recognised and attended to in order to develop and realise the potential of any technological change. Contextual activities typically take place in the individual, interpersonal, social, cultural, organisational, commercial, financial, economic, policy and regulatory spheres.
Previous work with the cold storage industry has demonstrated the important influence that contextual issues such as individual and organisational attitudes and behaviours, as well as cultural and market conditions, can have on the adoption of low carbon technologies and energy efficient practices. Non-technical barriers and enablers to technological change have been identified, which have then informed the development of strategies designed both to remove or overcome the blockages and encourage and diffuse any helpful practices.

Building on this knowledge, this work package has two key objectives:

- to investigate and identify the non-technical, contextual barriers and enablers to the refrigerated warehouse and food processing sector in realising the low carbon potential of CryoHubs (defined here as cold energy storage systems that integrate renewable energy sources with liquid air energy storage).

- to examine the role that alternative business strategies and models have to play in delivering transformative CryoHub technology and in increasing its market uptake.

2.2.1. Purpose of deliverable

The purpose of this deliverable (8.1) is to review relevant literature and research as it relates to organisational change related behaviours, socio-technical transitions and organisational responsiveness to the adoption of renewable energy and other low carbon and energy efficient technologies and practices especially where relevant to the cold storage and food manufacturing sectors in the EU.

The report focusses on reviewing literature and previous research in three areas:

- Change at the level of the individual – behaviour change and social practice theory and frameworks in particular as they relate to individual energy behaviours.
- Organisational change - the elements of personal and interpersonal behaviours, management and operating culture and external business environment, which influence the uptake of low carbon and renewable technologies within individual organisations.
- System change - socio-technical barriers and enablers that impact the diffusion of low carbon and renewable technologies across business and society

3. Behaviour change and social practice theory and frameworks

3.1. Models and theories of behaviour change

This section outlines some of the key models and theories of behaviour change in relation to energy, drawing on evidence from behavioural economics, social psychology and sociology to examine different ways of changing energy behaviour.

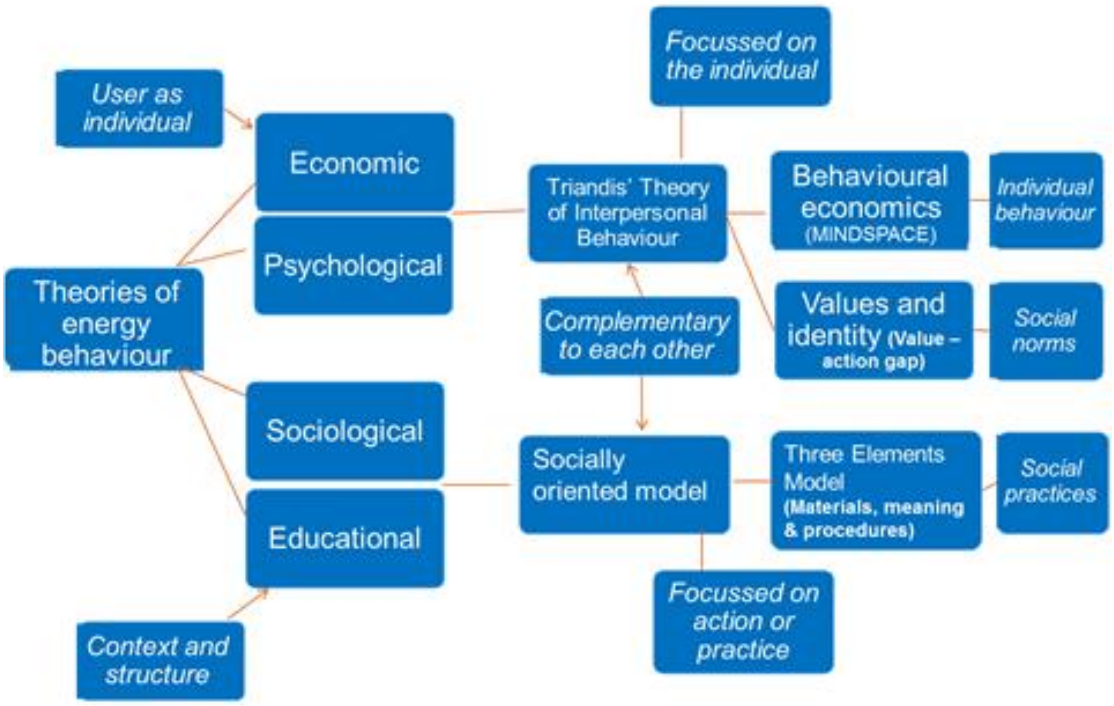
Distinct theoretical approaches to understanding energy behaviour originate from different academic disciplines.

- Economic theories: energy is a commodity and consumers will adapt usage in response to price signals (can work in the short term but cold weather will increase use whatever the cost).
- Psychological theories: energy use can be affected by stimulus-response mechanisms and by engaging attention (suggests that people will respond to information about their energy usage such as home energy displays or salient billing information).
- Sociological theories: energy use is largely invisible, energy systems are complex, and daily practices are significant (takes the view that people do not directly use energy, they carry out activities and practices that consume it, each activity requiring particular targeting).
- Educational theories: efficient energy behaviour is a skill that is learned through experience in specific situations (highlights that everyone is individual, with different levels of skills, understandings and motives).

In his paper, 'An Introduction to Thinking about 'Energy Behaviour': a Multi Model Approach', Dr Tim Chatterton[1] introduces these approaches to show how they view the same issue from diverse perspectives and to consider how they can be used to inform both policy making and social marketing communications activities.

The diagram below depicts some of the relationships between behaviour change theories. These are explored in more detail in the following sections.

Behaviour change theory schematic

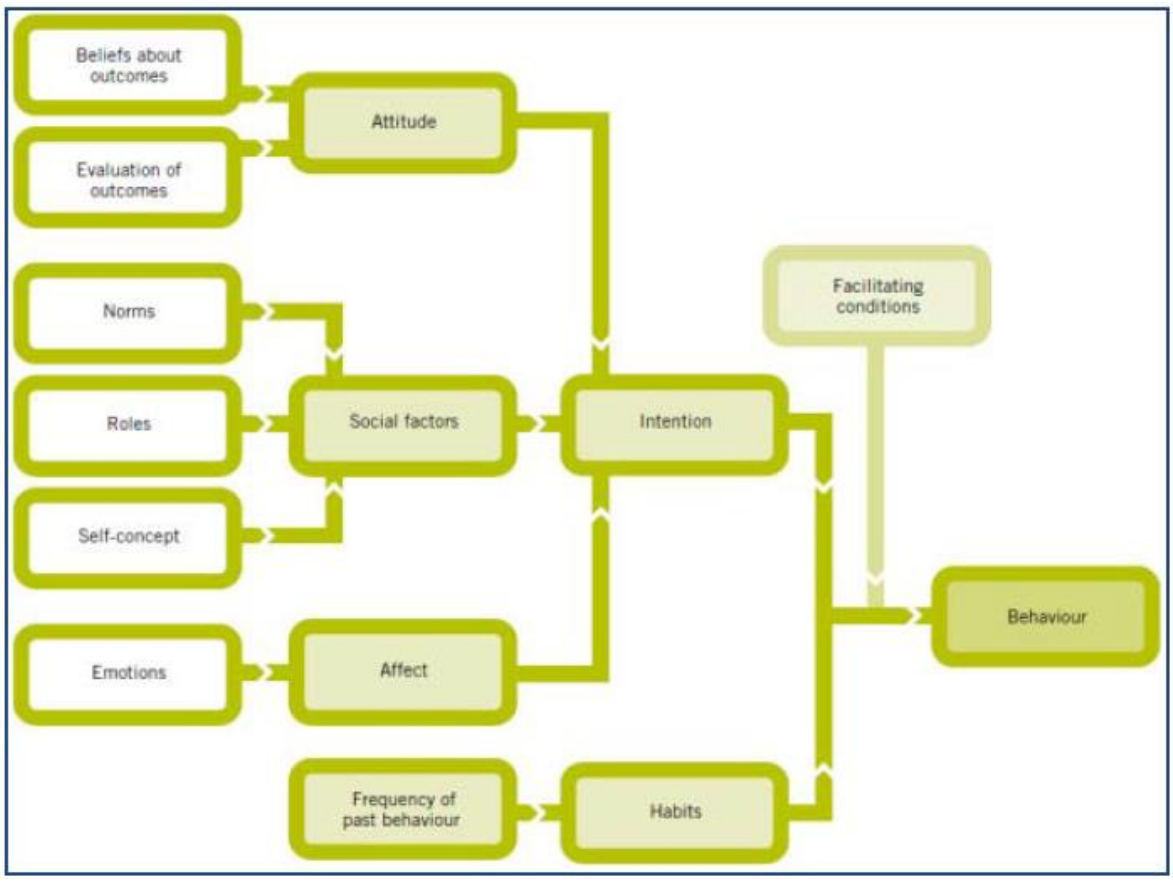


3.1.1. Triandis' Theory of Interpersonal Behaviour

This model helps us understand how real-world behaviour can be broken down into different elements and stages, each of which can be interpreted using a mix of the theoretical approaches. Triandis' linear model of behaviour portrays behaviour as the result of a constant stream of choices made on the basis of (largely) rational decisions made by individuals. The Triandis framework can be used as a tool to view and break down decision-making and behaviour processes, in order to compare and integrate elements of behaviour theory into policymaking and communications activities.

[1] CHATTERTON, T. (2011) Introduction to Thinking About Energy Behaviours – A Multi-Model approach for DECC

Triandis' Theory of Interpersonal Behaviour (1977 – reproduced from COI, 2009



The basic core of the model are the 4 boxes on the right-hand side on the diagram above: Intention, Habits, Facilitating Conditions and Behaviour. These set out the basic relationship of conscious/sub-conscious decision making (Intention), automatic routines and actions (Habits), and external barriers or enablers (Facilitating Conditions) in contributing to what we finally see as Behaviour.

3.1.2. Behavioural economics

Economics has been the major tool by which government has sought to steer people's behaviour. While economics has traditionally assumed that correct pricing and better information is sufficient for people to make decisions, behavioural economics (such as 'Nudge' theory) takes account of evidence from social psychology showing that people do not always make strictly rational decisions, mainly because the brain is hardwired to take mental shortcuts when making decisions (to get the optimal if not the best result at the time – this is known as heuristics).

A vast amount of work has been done in the fields of social psychology and behavioural economics. For example, work undertaken by the UK Institute for Government in 2009 produced the MINDSPACE mnemonic, which sets out a nine key elements for policy makers to consider when using this approach in behaviour change work. The table below applies MINDSPACE to the UK Green Deal, an initiative to encourage the uptake of energy efficiency technologies by homeowners, giving examples and inspiration from energy efficiency initiatives

MINDSPACE and the Green Deal

Effect	Examples and inspiration
Messenger We are heavily influenced by who communicates information Includes: • Role of experts • Peer effects • Importance of consistency	• DECC's 'pay as you save' pilots suggested 50% of customers change their mind about which measures to install in their home following a visit from an expert assessor. • Expert assessments are a key part of energy efficiency policies in other countries e.g. Queensland 'Get Climate Smart' scheme in Australia. • This approach has also been used in the UK e.g. Groundworks "Green Doctors" local advisers.
Incentives Our responses to incentives are shaped by predictable mental shortcuts, such as strongly avoiding losses, discounting of future rewards	• Council Tax credits, financed by British Gas, have been used effectively to drive uptake of energy efficiency measures in over 50 local authorities – evidence from these areas shows people love getting a tax discount. • The time limited boiler scrappage scheme was also a great example of effective use of incentives – a £400 money-off voucher was used for new, A-rated boilers which replace old, inefficient models.
Norms We are strongly influenced by what others do And need consistent reminders of this over time	• There is emerging evidence that area based approaches can drive take up. The Community Energy Saving Programme (CESP) encouraged energy suppliers to partner with local authorities to deliver energy efficiency measures in highly targeted deprived areas. Feedback shows this approach works well, driven by neighbours seeing work being done and talking to each other. • Similar results have emerged from some Low Carbon Communities Challenge projects, such as the Meadows in Nottingham, where solar PV installation got neighbours talking to each other about how to get involved.
Defaults We 'go with the flow' of pre-set options	• The London Sustainability Exchange piloted 'Sustainability Starter Kits' as part of welcome packs for new Housing Association tenants. • Defaults have also been used in the past when developing other energy efficiency policies eg for instance to gain access to a Low Carbon Buildings Programme grant for installing microgeneration, householders had first to fit basic energy efficiency measures.

Salience Our attention is drawn to what is novel and seems relevant to us	• A Low Carbon Communities Challenge project in Totnes installed a public digital display to demonstrate energy efficiency savings from its retrofit. • The City of Newcastle in Australia has a ClimateCam® Billboard showing hourly updates on actual electricity consumption and a comparison to the City average.
Priming Our acts are often influenced by sub-conscious cues	• Some real-time electricity displays are programmed to glow, flash or go red if consumption is high. • Insulation prominently displayed in DIY stores could help. For instance B+Q have now placed all their energy saving products in one area at the front of many stores.
Affect Our emotional associations can powerfully shape our actions	• In Devon, the 'Cosy Devon' rebranding resulted in triple the number of enquiries they would usually expect in the month following launch. • Kirklees Council's well-publicised 'WarmZone' branding uses a similar approach.

Commitments
We seek to be consistent with our public promises, and reciprocate acts
	• The 10:10 campaign, a movement which asked individuals, businesses and organisations to sign up publically to cutting their emissions by 10% in 2010.
	• The Isle of Eigg (a Hebridean Island with a fully renewable electricity supply) '5kW' challenge also uses commitment:
	  ○ In 2008, the 83 islanders pledged to keep their total electricity use <5kW to manage demand for power.
	  ○ They use energy meters and information stickers on key appliances to help them manage consumption.
	  ○ Their system sets off a trip switch which shuts off power to the household if the limit is exceeded.
	  ○ To get reconnected involves a call out charge of £20.
	  ○ Only 3 call outs were received in the first two years.

Ego We act in ways that make us feel better about ourselves and like to think of ourselves as consistent	• Evidence from DECC's Pay As You Save pilots suggests that once people have had insulation fitted, they are likely to be motivated to talk to others about it. Indications are that it makes them feel good about themselves, even if it was originally motivated by a desire to save money or make their house warmer.

Key elements of the MINDSPACE mnemonic are reinforced in the 'Behaviour Change and Energy Use' report by the Behavioural Insights team at the UK Cabinet Office[2], which also starts from the premise that social, cognitive and behavioural factors are important in explaining why many people have not yet introduced changes that could help them to enjoy cosier homes and lower energy bills. For example:

- Concern about the environment does not always translate into taking practical steps to reduce domestic energy consumption.
- Although many energy efficiency measures have been proven to be highly cost-effective (eg loft insulation or cavity wall insulation), and therefore a 'rational' thing to do, many people are yet to introduce them.

The report cites three of the most significant behavioural insights, which relate to (i) our tendency to 'discount the future'; (ii) the power of social norms; and (iii) the use of defaults:

(i) Discounting the future. People often have a tendency to 'discount the future' – i.e. they may prefer a smaller reward today over a larger reward in the future. One of the barriers to making energy efficiency improvements relates to the fact that the benefits are accrued over a long period of time, whereas the costs associated with them are immediate and sometimes large.

(ii) Social norms. Behavioural insights tell us that people are heavily influenced by what others around them are doing. How can social norms encourage the adoption of green behaviours? Can the diffusion of norms be encouraged through existing social networks?

(iii) Defaults. One important lesson from behavioural economics is that individuals tend to go with the flow of pre-set options, or defaults such as pre-sets on heating and cooling systems.

3.1.3. Values and identity

How people perceive themselves is often crucial to how they consider it appropriate to act, whether by wanting (consciously or sub-consciously) to follow social norms, or by wanting to try and mark themselves out as different. Campaigning groups like WWF (through their 'Common Cause' approach) emphasised the need to focus on 'engaging' specific pro-social (humanitarian) or pro-environmental values within people and society in order to achieve significant shifts in behaviour, especially in relation to climate change.

There is extensive academic literature on behaviour change and pro-environmental behaviours, primarily located in social psychology and economics, where the individual and his/her behaviour is taken as the unit of analysis. Many models of individual behaviour focus predominantly on 'internal' barriers to change such as (lack of or inappropriate) knowledge, attitudes, values, motivation, emotions, personal habits and routines as well as self-efficacy (self-perception of the ability to change). Persuasion theory, for instance, hypothesises that behaviour change can occur if new information influences individuals' attitudes, emotions or motivation (Jackson 2005).

A key example of this work is the Pro-Environmental Behaviours research and development, which was undertaken by the UK Government's Department of Environment, Food and Rural Affairs (DEFRA) between 2008 and 2011 and which is outlined below.

[2] CABINET OFFICE., DECC, CLG (2011) Behaviour Change and Energy Use

The 2008 Pro-Environmental Behaviours Framework

Individual predisposition to environmental issues influences a person's attitudes and behaviours. In 2008 The UK Government's Department of Environment Food and Rural Affairs (DEFRA) issued their *Pro-Environmental Behaviours Framework,* which pulled together evidence on public understanding, attitudes and behaviours, identified behaviour goals and drew conclusions on the potential for change across a range of behaviour groups. It was designed as a tool to support policy development and implementation within DEFRA itself, in other Government Departments and externally. Below are some key elements of the 5 parts of the framework and their relationship with low carbon change.

i A set of core **principles and approaches** for encouraging more environmentally friendly behaviour. The following inform the development of low carbon activities in an organisational context:

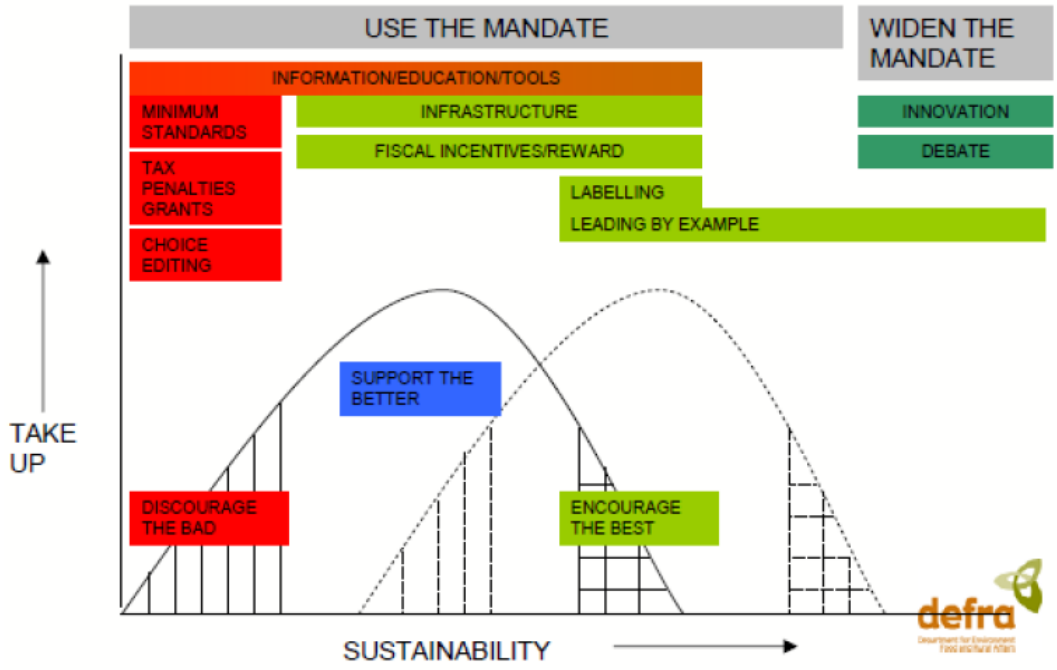
The big picture

- There is no single solution that will motivate a mainstream audience to live a greener life. It requires multiple, integrated interventions.
- Draw on all the interventions available to you. Develop an intervention mix combining tools from across the policy and communications spectrum.
- Build an understanding of the public and societal trends. Consider public attitudes, beliefs, motivations, barriers, and current and desired behaviours. Review your options for interventions against these insights. Use key insights and segmentation models to develop targeted approaches.
- Understand the behaviours you are asking people to adapt or adopt. Tackling habits, lifestyle choices or purchasing behaviours may need different tactics.
- Be clear what your organisation/programme can do as well as what others are doing. Consider the role of government, business and the public.
- Work across sectors in designing and implementing programmes - evidence shows this makes interventions more successful.
- Accept that outcomes of behaviour change interventions are difficult to predict; we need to take risks and pilot activity.
- Recognise securing behaviour change is a long-term process not a single event.
- Demonstrate consistency.

The specifics

- Address both internal and external motivations and barriers.
- Optimise common motivations and barriers. Use non-environmental motivations.
- Recognise the role of social norms, identity, and status for moving towards greater adoption of pro-environmental behaviours
- Use 'opinion leaders' and trusted intermediaries to reach your audience.
- Recognise the value in joining up environmental issues for people, as well as joining up organisations' work and messages.
- Give feedback on progress made. Consider when we can ask people or organisations to make commitments to being more pro-environmental.

The framework suggests a 'roadmap for environmental behaviours' shown below.



Where does this roadmap sit in relation to uptake of low carbon technology in the cold storage sector? One view is that EU-wide legislation to phase out certain cold store refrigerants for example is one way of 'discouraging the bad' whilst incentives such as low interest loans may be employed in some instances to 'support the better' such as the introduction of energy efficient equipment.
In its framework DEFRA considers that products and services are central to the change process and, in particular, that both Government and business should be prepared to 'choice edit' in order to remove the most unsustainable products and services from the market place. The use of life cycle analysis (product roadmaps) is also recommended in order to clarify where intervention is best applied.

ii A set of 12 headline **behaviour goals** (shown below), covering the main areas of consumption: food and drink, personal travel, homes and household products, and travel tourism. Of the 12 goals, 9 relate to home energy, waste and water issues, 3 relate to travel and 3 to eco-products. If the Government is successful in achieving these behaviour goals within a domestic context, what impact might this have on attitudes and to environmental issues in the workplace? Employees who show both awareness of the issues and a positive attitude towards taking action are more likely to be exhibiting environmental (including energy efficient and low carbon) behaviours at home.

iii Consumer insight and evidence base: includes an assessment of what kinds of actions people are already taking and their relative ability and willingness to do more; setting out common motivators and barriers to change. Motivators include:

- a behaviour results in a feel-good factor or provides a sense of ***altruism*** and some social currency;
- new behaviours fit within current lifestyle and /or are ***expected by society***;
- individual benefits accrue from taking up the behaviour eg ***lower financial outlay***, alleviates guilt;
- behaviours are ***easy to do***;

- people understand why they are being asked to act and ***what difference their actions will make***; people want to be part of something.

However in terms of barriers:

- There are external limits to choosing certain behaviours eg ***infrastructure limitations***, financial constraints, working patterns, demands on time.
- Belief that taking on new behaviours will have a ***negative impact on current lifestyle*** (particularly time) and restrict current freedoms (particularly convenience).
- Maintaining one's self identity and ***negative perceptions of green 'lifestyles'*** and products.
- Disempowerment – a sense of disconnect between the scale of the problems and the individual's contribution - that ***individuals cannot make a difference***.

iv The framework presents an **environmental segmentation model** that divides the public into seven clusters, each sharing a distinct set of attitudes and beliefs towards the environment.

The evidence of both the consumer insight and population segments of the framework suggests that there are multiple opportunities to introduce low carbon behaviours to all people representing all segments of the population but that it will be necessary to ensure that the offering and associated communications are targeted to relate to each segment's specific beliefs and motivations and to connect these to the benefits that an energy efficient/low carbon organisation or economy can offer (as shown in the examples below).

The seven (UK) population segments

Segment	***Typical statements of attitude***	***Potential responses to low carbon working in an organisational context***
Segment 1: 'Positive greens' 18% of the population (7.6 million)	"I think we need to do some things differently to tackle climate change. I do what I can and I feel bad about the rest"	These segments are likely to be amenable to trying out new ways of doing things. They are potential champions or ambassadors of energy efficiency and low carbon working.
Segment 2: 'Waste watchers' 12% of the population (5.1 million)	"'Waste not, want not' that's important, you should live life thinking about what you're doing and using"	
Segment 3: 'Concerned consumers' 14% of the population (5.7 million)	"I think I do more than a lot of people. Still, going away is important, I'd find that hard to give up..well I wouldn't, so carbon offsetting would make me feel better"	Very likely to support new practices and policies provided they are not personally overly restricted by them.

Segment 4: 'Sideline supporters' 14% of the population (5.6 million)	"I think climate change is a big problem for us. I suppose I don't think much about how much water or electricity I use, and I forget to turn things off..I'd like to do a bit more"	Likely to accept new practices but need reminding as good environmental practice behaviours are not top of mind.
Segment 5: 'Cautious participants' 14% of the population (5.6 million)	"I do a couple of things to help the environment. I'd really like to do more..well as long as I saw others were"	There are opportunities to engage this segment by normalising energy efficiency best practice.
Segment 6: 'Stalled starters' 10% of the population (4.1 million)	"I don't know much about climate change. I can't afford a car so I use public transport..I'd like a car though"	These segments are more likely to respond if making good practice is part of their job description or a KPI or other incentives are used (carrots or sticks).
Segment 7: 'Honestly disengaged' 18% of the population (7.4 million)	"Maybe there'll be an environmental disaster, maybe not. Makes no difference to me, I'm just living my life the way I want to"	

Motivations for pro-environmental behaviours research 2010

This six-month research project was commissioned as part of DEFRA's Sustainable Consumption and Production research programme in the UK. Its main aim was to develop a better understanding of the role played by key identified social and psychological phenomena in motivating or hindering pro-environmental behaviour change, with particular focus on identity and social norms. The research examined these phenomena in five of the seven segments from DEFRA's 2008 segmentation model. These segments were Positive Greens, Waste Watchers, Concerned Consumers, Sideline Supporters and Cautious Participants.
The study, which was a combination of desk research, in-depth interviews and focus groups, had three key objectives:

- Explore in depth the motivators and barriers that influence different pro-environmental behaviours in relation to five of the seven segments.
- Explore why some motivators are relevant to certain segments but not to others, and explore the implications this has for efforts to encourage pro-environmental behaviour change.
- Finally, and most importantly, investigate the way in which self-identity, social identity, social norms, guilt and agency motivate or hinder pro-environmental behaviour, and how individuals construct their understandings of these motivating factors.

The research found that 'motivations' are complex and contested and for each individual, different motivations interact in a variety of different ways producing a unique pattern of behaviour. However, some areas were (cautiously) identified where there seemed to be consistency and coherency in the relationship between motivations and environmental behaviour, and the

research tried to understand how these motivations would operate for different groups of people and across different behaviours. In summary:

Changing perceptions of pro-environmental behaviour

- In general, most of the individuals and groups in the sample felt that undertaking a small amount of pro-environmental behaviour was no longer seen as being unusual or the preserve of activists. For the most environmentally active segments, there appeared to be an expectation of some environmental action as normal, responsible behaviour. Indeed, not undertaking any pro-environmental behaviour was perceived to be lazy or selfish. This is particularly true of recycling.

Identity

- Respondents were invariably negotiating their environmental values and identities alongside other rewarding sources of identity and self-esteem, such as work, family, home and a sense of self as a good person. How important these different sources of identity were to the individual affected the likelihood of environmental actions.
- Not all of the self-identities which supported pro-environmental behaviours were overtly environmental. Instead identifications with frugality, anti-waste, anti-consumerism and self-sufficiency acted alongside more 'green identities' to help stimulate behavioural uptake. Perceptions of the self as non-materialistic, unselfish and thoughtful were facilitated through undertaking some pro-environmental behaviours, especially for those who perceived a social expectation of action.
- Not all pro-environmental behaviours carry the same kind of meaning personally, socially or morally. Some behaviours may enhance social status and self-esteem, others may hinder this. This is because people are negotiating a range of different self and social identities; and different behaviours can speak to those different identities. For example, some participants think that owning a small car or buying second hand clothes will not provide them with the personal and social rewards that they feel they deserve as a result of their hard work and successful careers. For others, the car was essential to ensuring their children could attend the best school or arriving at work looking professional. Alternatively, some smaller behavioural changes can enhance the perception of the self as a good person; larger changes may allow the more proactive environmentalist a sense of consistency or authenticity from living their values.
- The prevailing discourse of 'doing my bit' appeared as the predominant environmental position for many in the sample. More than just a rhetorical expression, this allows individuals to validate themselves as non-materialistic, unselfish or responsible whilst at the same time protecting other important identities and behaviours. It facilitates a sense of personal responsibility and action for the environment; in line with social expectations and the actions of important others, whilst not demanding that the individual has to do a lot or give up valued goods. This becomes played out through a notion of 'balance' between self and society, and between luxury and morality.

Social Norms

- People tended to position their behaviours as being in line with those of their friends, family or neighbours. For those participants with an active pro-environmental social group, some pro-environmental behaviours were supported by shared meanings of being a good person and a group norm that defines what is acceptable or valued behaviour. However, for others in the sample without such a social group, undertaking some pro-environmental behaviours had little social value and might even conflict with their social identities.

- Differences were apparent in the willingness and ability of individuals to undertake behaviours which might conflict with their desire to maintain or enhance their status and membership within a social group, especially those behaviours perceived to bring social stigma. Strong personal norms or sense of self in relation to a behaviour were the primary motivations for breaching social norms. However, a lack of resources could also lead people to breach social norms. Conversely, those less certain in their self or social identities seemed less likely to want to breach social norms or give up high status behaviours, for example by buying second hand goods or swapping a large car for a smaller one.
- A range of different actors appear to be working to create new social norms in relation to pro-environmental behaviours. Friends, family and local community influence seem crucial to changing norms. However, government, the media (including celebrity chefs as agents of consumer morality), and social institutions such as schools and workplaces are also influential. The workplace appeared as a useful source of new social norms for those without an active friendship group. At the same time, improvements in infrastructure that facilitate environmental action normalise changes in behaviour, reduce the justification for doing little or nothing, and can signal a wider change in social expectations.

Agency

- Not all action was premised on the belief that it would make a major difference to the environment or climate change overall. Indeed, for those with strong pro-environmental values and identities personal accountability appeared to be more important than the efficacy of small changes in behaviour. Moreover, doing nothing for the environment is not considered by some to be a positive or self-enhancing option. For those who saw their role as 'doing their bit' alongside others in society, personal responsibility as part of a collective effort appeared to be more important than worrying about what difference any single action might make in isolation. However, more will need to be done to convince people of the efficacy of large scale actions particularly if they require more people to make sacrifices to their current lifestyles or compromise their self or social identities.

Guilt

- Both the findings on self-identity and guilt suggest individuals are more likely to undertake actions which fit with specific moral standards. For example, those concerned about climate change were more likely to say they would feel good or guilty in relation to whether they undertook climate change related behaviours or not, whereas those concerned about waste or strongly identified with frugality were more likely to say they would feel good from undertaking waste saving behaviours or guilty about wasting food, water, energy or money.
- Social comparison appeared to be a key process in managing guilt related to pro-environmental behaviours. Possibly because of the construction of personal environmental responsibility as part of a larger set of collective action, people offset guilt they might feel about not doing enough by comparing their actions favourably with other people's. So, some people may only recycle but they can reduce their feelings of guilt by pointing out that they are still doing a lot more for the environment than many other people here and in other countries.

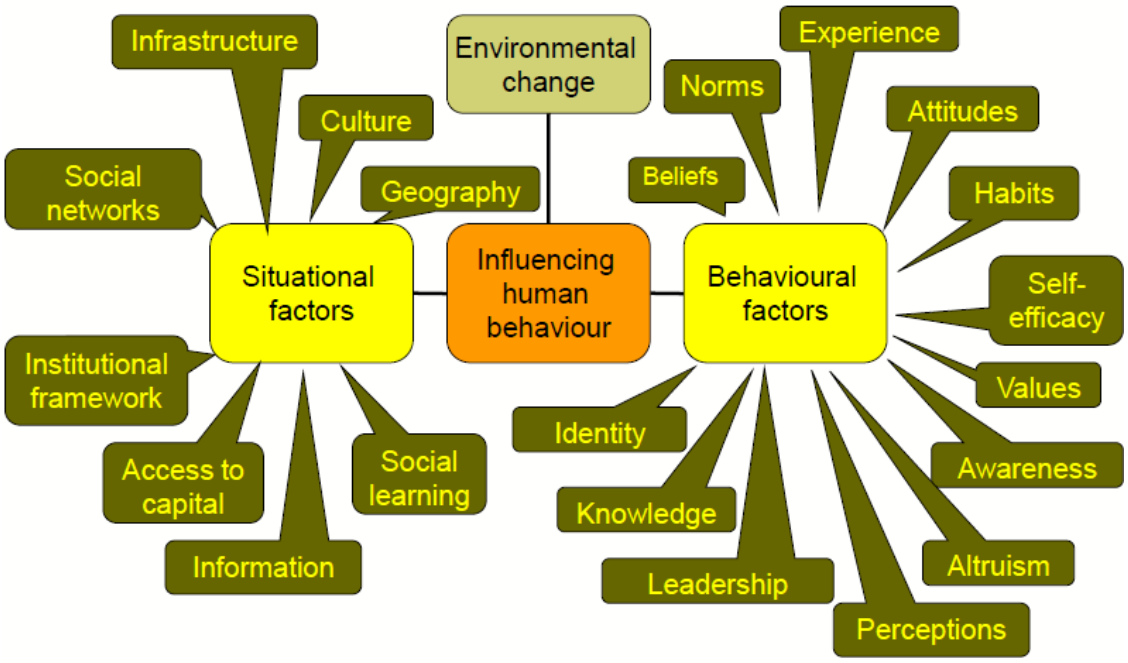
The research concluded that self-identity, social identity, social norms, guilt and agency are all important factors in motivating pro-environmental behaviour. Whilst few of the pro-environmental behaviours examined showed signs of being current social norms, many appeared to have the ability to become social norms. Overall, a growing perception of a need to undertake some pro-environmental behaviour as part of being a responsible person was identified.

The sustainable lifestyles framework 2011

The Sustainable Lifestyles Framework was developed as a tool to support DEFRA and a wide range of other organisations and communities to develop effective approaches to influence behaviour. The Framework outlines a set of key behaviours that constitute a sustainable lifestyle, identifies best practice to influence behaviour and key insights on why some people act, all informed by a robust evidence base.

The 2011 Framework built on the 2008 Framework for Pro-environmental Behaviours report and drew on developments in the evidence base and feedback received from stakeholders (such as civil society organisations, academics, and local authorities as well as Governments and organisations overseas) in the intervening years. It set out DEFRA's approach to understanding and influencing behaviour; outlined insights from analysis of the evidence base for effective approaches; and the motivations and barriers to action to inform the development of effective interventions.

Factors contributing to human behaviour (DEFRA 2011)



Key elements delivered by the framework:

i) Core principles to influencing behaviour

- **Multi-disciplinary approach** to understanding **and** influencing behaviour
- **Multi-disciplinary analysis** –building and reviewing a significant and respected evidence base drawing on social research, behavioural economics, social marketing and other specialisms
- **No single solution** –behavioural interventions are most effective as *integrated package of measures* to mobilise action, drawing on a spectrum of policy and communications tools e.g. both coercive and non-coercive
- **Start where people are** –focus policy development on understanding people and how different groups respond rather than what we assess as a 'rational' response

- **Rationale** for intervention goes beyond 'traditional' market failures (such as information deficits) and recognises the need to address breadth of barriers and motivations for different groups
- **'Behaviour change' vs. influencing behaviour** –'behaviour change' can imply top-down approaches. Rather, talk about interventions to 'influence behaviour' to recognise that sometimes people are being encouraged to maintain behaviours; to undertake current behaviours more frequently; other times to adopt new behaviours; and sometime to adapt current behaviours
- **Use behaviours and practices as a route through to exploring the issues** from different perspectives; the drivers at personal and societal levels; and where action will be most effective

ii) To enable sustainable lifestyles we need to understand

- The key behaviours people and businesses would maintain to support sustainable lifestyles
- What people/business are currently doing, what different groups will do, and with what level of support
- Where the key impacts are (e.g. in production, use, disposal)
- The motivations and barriers to action (e.g. benefits of current action vs. desired; level of existing infrastructure etc.)
- The package of tools/interventions that will secure the change and the way these can be developed to be most effective
- Who should develop and deliver these and where partnership is key (e.g. government, business, communities, civil society, membership organisations etc.)

Understanding all of this informs the development of interventions that address motivations and barriers at a personal and societal level

iii) Identification of the key sets of behaviours that constitute a sustainable lifestyle

There are 1000s of behaviours that can contribute to sustainable living –many people are not sure of the 'right' behaviours; indeed, civil society and other organisations can find it difficult to identify the areas to focus on

- By undertaking a collaborative and extensive review of sustainable behaviours, the research identified those key for a sustainable lifestyle. This involved input from over 100 representatives from business, civil society, other government departments, local authorities and DEFRA policy teams thus providing a valuable resource for DEFRA and other organisations:
- A collaborative, transparent, and evidence based approach gives other organisations the confidence and capacity to use them to shape activity
- Providing a priority set of behaviours (with as much specificity as possible) offers a wide range of organisations a focus for their activity, which optimises the value of collective action
- The research identified a set of 9 headline and, within these, 30 key behaviours - assessed on the basis of evidence of sustainability impacts e.g. CO2, water, biodiversity and wellbeing, and potential for action (i.e. current uptake; potential uptake without major infrastructure change)
- Importantly this set of behaviours are not asks for individuals to act –they represent a set of behaviours that constitute sustainable lifestyles. For example, effective action to reduce the impacts of these behaviours may not be targeted directly at individuals/ communities and instead be through business or government.

iv) Evidence based segmentation model

The research worked with the 2008 evidence based segmentation model to inform which approaches would be most effective with different population groups (segments)

- Research informed the basis of the model - people's values, beliefs and attitudes towards the environment
- Wider data built understanding of the original 7 segments: Positive Greens; Waste Watchers; Concerned Consumers; Sideline Supporters; Cautious Participants; Stalled Starters; Honestly. Segment profiles were built to include willingness to act; reported behaviours, socio-demographics etc. For each segment, willingness and ability to act was assessed along with potential to do more, and the types of measures most likely to enable this using the four broad groups in DEFRA's 4Es tool (see below)
- For example, an approach that focuses on making it easy for people to act through providing the infrastructure and facilities (*enable*) and *engaging* people using creative approaches and trusted intermediaries is unlikely to increase uptake across the whole population. Such an approach is most likely to engage Positive Greens, Concerned Consumers, and Sideline Supporters

v) Why people act and why they don't - using the example of eco-upgrading their homes

What others are doing is key

- Some think it is 'someone else's responsibility' to take action –e.g. energy suppliers, business & Government, but some are sceptical about their motives for action
- People make (sometimes wrong) assumptions about modern products and levels of choice-editing (e.g. believing it to be more extensive than it is). They expect Government and business to make it easier for them to act as well as acting themselves
- Lack of social norms –while using energy efficient light bulbs is norm for many groups, this is not so for other energy efficient behaviours. In addition, these behaviours are not visible or status behaviours

Skills and ability more important than understanding

- Ability to act is determined by people's access to products & knowledge of options; constraints (e.g. cost); level of convenience (e.g. how easy it is to install)
- Remains confusion about what retro-fit measures are & people struggle to identify a need for them
- Hassle and disruption –including effort associated with choosing the fix or technology, finding a reputable installer, preparation to have the work done, and the work itself
- Fix, forget, and poor in-use support –it's not sufficient to just install technological solutions, people need to be supported to use technology effectively with feedback and engagement over time. Without this retrofitting measures can have unintended consequences e.g. people turn up the heat

What's in it for me is important

- Identity –measures need to live up to people's expectations of 'normal' products. Some retro-fit measures could be status behaviours and a desire to improve social-status could be hook to encouraging take-up (e.g. to move take-up beyond just the early adopters)

- Cost is a barrier to action –e.g. people want to save money but over-estimate savings; savings are often not sufficient to overcome other barriers (e.g. hassle). Initial outlay can be a barrier e.g. for groups not able to afford the upfront costs
- Aesthetic tastes (fashion/style) and fit with lifestyle (e.g. it's not for me) are central to why people reject retrofit technologies

'It just makes sense' though making a difference matters

- Use a mix of emotional and rational cues to encourage take-up –e.g. use people's desire for comfort, dislike of wastefulness, and emotional cues like 'warmth' rather than just saving energy and money
- People need feedback on progress and info to validate the need to act e.g. there is a lack of understanding between 'just having insulation' and having 'good insulation' that meets standards
- There are perceived risks associated with taking up new and 'untried' technology –e.g. people need to know how the technology will look/work, that technologies are reliable.

vi) Behavioural theory underpins the approach –though there is no one winning model to deliver 'behaviour change'

The research concludes that models are concepts that help to understand behaviours –but not how to influence behaviour Insights from both behavioural models and theories of change to inform the development of effective interventions.

- **Models of behaviour** identify the ***key factors that influence behaviour.*** This helps to assess which approaches will be effective with different groups. Such models help to understand specific behaviours, by identifying the underlying factors which influence them. Factors include: values; beliefs; attitudes; existing and developing norms; sense of agency; the role of habit; affect. An example is Ajzen"s Theory of Planned Behaviour.
- **Theories of change** show ***how behaviours can change over time.*** This helps us identify types of intervention more likely to be effective over time, based on where people are, as well as suggesting broad approaches to design, delivery and evaluation. Examples are diffusion models (such as the 's curve' from early adopters through to laggards) and 'stages of change' models.

vii) Best practice principles for delivering change

No single solution

- Need an **integrated package of interventions** –most effective are multiple measures at multiple levels drawing on full range of policy and communications tools
- It's a **long-term** process –effective packages are likely to develop over time and draw in different tools
- Need to **take risks and pilot innovative approaches** to inform delivery
- **Different approaches and packages** are effective **for different population groups;** where seeking to break habits, there are specific techniques to include
- **Effective solutions may be linked to non-environmental initiatives**

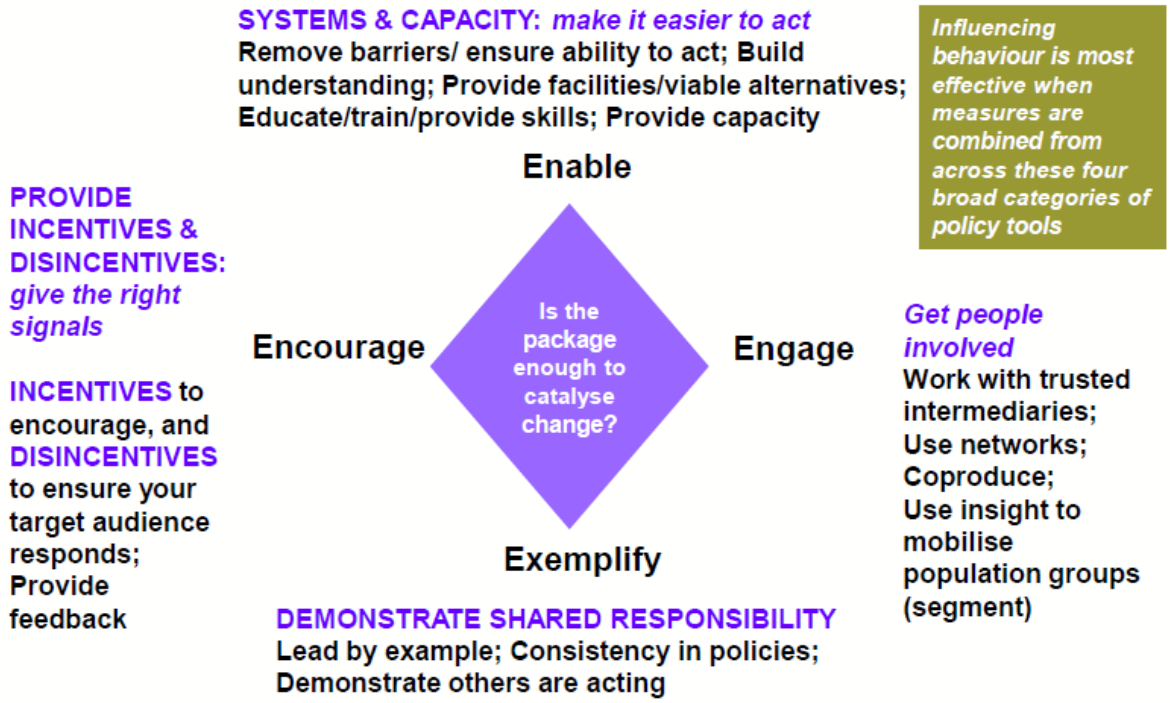
We will if you will

- **Work across the triangle of change** (government, business, civil society, individuals and communities) -collective action is needed to enable others to act and Government has a facilitation role to encourage action at all levels
- **Government, business and civil society need to act themselves** and **be consistent**
- **Increase choice editing** (removing the worst offending products) and **enable sustainable choices**
- **Address cross-cutting barriers** and **ensure** target groups are **able to act** e.g. exemplification; infrastructure and facilities available, accessible, and promoted

Start where people are

- **Understand where people are starting from** and where they'd like to be
- Take a **lifestyle approach** to engagement –e.g. make the links across policy areas and make the connections to how people experience the behaviours and practices
- **Work with communities** to identify the issues they face and collaboratively design solutions
- **Work with what we know motivates different groups** –e.g. go beyond environmental concern and saving money
- Work with **trusted intermediaries** (civil society, business, communities)
- **Engage the 'influencers'** and **catalytic individuals** in people's social networks

4 E's model – one tool to ensure a mix of interventions



NB DEFRA's 4Es tool is embedded in the UK Government's Mindspace tool within the 6Es, which highlights the importance of initial exploratory work and evaluation to add 'explore" and 'evaluate'

Designing the most effective mix is driven by a number of key factors which shift the balance and nature of the interventions needed to deliver change (including changing the importance of regulatory measures in achieving the outcome).

The importance of the mix of measures It's feasible that a mix of measures that *engage* and *enable* will lead to 'change' though with those most willing and able to act. It's likely that some other groups will act if *exemplification* measures are also integral to the mix. For others, there is a role for regulation, fiscal measures, minimum standards or voluntary standards before behaviour is influenced.

The approach and the mix of measures drawn from across the 4Es need to address the core motivations and barriers; what supports the current behaviour (and future behaviour); and draw on wider best practice, such as the need for collective action to enable change working across the 'triangle of change' (government; business; individuals/communities; and civil society).

3.1.4. Social practices

Although behaviour change and pro-environmental behaviour theories and models emanating from social psychology and economic traditions has dominated the popular policy discourse to date, in the social practices approach the individual is no longer taken as the unit of inquiry. Instead focus is moved to the actions (or practices) themselves. So for example, rather than trying to influence decisions made by individuals it looks at energy consuming actions such as cooking, cleaning, taking thermal comfort and showering/bathing.

Elizabeth Shove has long criticised frameworks that focus on individual's responsibilities and the change that their individual behavioural choices can bring about. This channels attention away from the role that governments and other actors play in 'sustain[ing] unsustainable economic institutions and ways of life' (Shove[3] 2010). Through an analysis of the interaction of individuals and their social contexts, sociological accounts are better placed to understand the impact of policy frameworks and broader social norms, discourses, power relationships and unequal distributions of resources.

While there is no single agreed definition of 'practice', there would be broad agreement that it entails routine types of activity or recurring 'doings and sayings' (Schatzki[4]). Such practices can reach from the common everyday (e.g. eating, travelling, cleaning, etc.) to more complex practices (e.g. business, farming, political practices, etc.).

Practice theorists argue that by focusing on social practices, we can understand how actors' 'agency' is linked to 'social structures'. Actors are neither completely free to act nor are their actions entirely determined by social structures. Rather, agency and structure are inter-related: actors continually (re)generate social structures through the social practices in which they routinely engage whilst those practices are themselves embedded in social structures.

In addition, practice theorists have analysed the role that physical artefacts and/or wider technical infrastructures play in the construction and reproduction of practices.[5]

Interactions with forms of technology are integral to the reshaping of practices: think, for example, of the use of computers, or the way that electric showers have replaced baths. And on a larger scale, 'systems of provision' can 'lock-in' particular practices, making it difficult or less attractive to engage in other forms of activity. One example is the way in which the development of motorway infrastructure led to a particular form of automobility (private car use over public

[3] Shove, E. (2010) 'Beyond the ABC: climate change policy and theories of social change', *Environment and Planning A* 42 (6): 1273-1285.
[4] Schatzki, T. R. (1996) *Social Practices. A Wittgensteinian approach to human activity and the social*, Cambridge: Cambridge University Press.
[5] Shove, E. (2003) *Comfort, Cleanliness and Convenience. The social organization of normality*, Oxford: Berg.

transport). Artefacts and broader infrastructures play a crucial role in establishing, stabilising and transforming practices.
Five different aspects of the contexts which co-constitute social practices can be distinguished, namely:

- *meaning* - the way in which actors make sense of themselves (their identities), their practices and their contexts. A focus on meanings also enables us to understand actors' motivations, desires, goals and emotions that are implied in their practices.
- *competences* - This refers to actors' mental and bodily skills of knowing what to do in a particular situation. Competences may be social – how to relate to other people involved in the practice – or technical – knowing how to operate a particular technology.
- *social structures* - are not independent from practices and actors, but rather constituted, reproduced and transformed by actors who engage in ongoing practices. At the same time, practices are also embedded in these social structures: structures 'frame' and stabilise practices. Social structures vary have different dimensions: particularly significant are discourses, social norms, rules and resources.
  Within society there are competing discourses, with some more significant than others. Consumer capitalism is one such dominant discourse, shaping the way we conceive of the world and what is possible. At present, discourses associated with environmental protection tend to be much weaker and in fact often become subsumed within more dominant discourses. So, for example, the discourse of ecological modernisation is one in which economic growth and environmental protection are reconciled; whereas more radical green discourse would require significant changes in our patterns of consumption (Dryzek 2005)[6]. These discourses also frame the emergence of various social norms, rules and institutions (including laws and regulations). As well as the material incentives that such rules can generate (e.g. through the tax system or the regulation of markets), they also reinforce social norms. Norms may well clash – for example, social norms associated with fashion are often in tension with those related to fairness (particularly towards cheap labour).
  Another approach to analysing social structure is in relation to the distribution of different types of resources across society and different social groups. Resources are the basis for 'capacities' to act and influence others. Therefore, they influence which types of practices actors participate in. Resources come in a variety of forms, for example, there are distinctions between economic resources (command over material, financial and natural resources), social resources (linked to social networks and groups)and cultural resources (forms of knowledge, information, education)
- *artefacts / infrastructures* – material things eg cold stores and broader infrastructures eg generation of energy and access to electricity. Such complex infrastructures can lead to 'lock in' where changing practices may require significant changes to large-scale technical networks, which are themselves maintained and reinforced by aspects of social structure (be it government policy, social norms, etc.).
- *environmental context* - resources are drawn from the non-human world to sustain practices: the natural resources that are consumed to produce goods and services; artefacts and infrastructures. Particularly relevant may be the impact of a potential future decrease in the availability of fossil fuel resources which are still a crucial condition for high-carbon lifestyles. Or the extent to which practices have been developed in response to particular environmental contexts: this explains, for example, differences between the

[6] Dryzek, J. (2005) *The Politics of the Earth: Environmental Discourses (second edition)*, Oxford: Oxford University Press.

construction of dwellings in hot and cold climates; or the capacity to grow food. The environmental context thus shapes practices, but is itself shaped by them as resources are removed (sustainably or otherwise), greenhouse gases emitted, landscapes 'managed', and so forth.

Social practices are not only embedded within these aspects of context, but also shape (generate, maintain and alter) them as practices are repeated or transformed. However social practices are also open to change because actors' meanings and competencies are flexible an can be transformed in the continuous re-enactment of overlapping social practices.

Shove and colleagues[7] suggest that change implies a transformation of the relationships between the different aspects or elements that constitute practices: 'meanings, skills and things'.

This approach focuses less on specific causes for change; rather, it provides an account of the ways in which elements of practices co-evolve in the process of practice transformation. However, if, as suggested above, meanings, competences, things, social structures and environments are understood as contextual aspects of practices (rather than 'elements' of practices), we can analyse the extent to which purposive interventions are successful or otherwise in affecting these aspects of practices and hence shaping practices themselves. For example, we can analyse the impact on everyday practices of particular policy reforms, price changes, changing social networks and so on. That said, as different factors leading to practice change are likely to be multiple, interrelated and historically specific, a simple and universal theory of practice change is unlikely to emerge.

3.1.5. Behaviour change vs social practice

In the context of moving towards a low carbon economy organised around more energy efficient practices and the application of innovative and renewable energy technologies, then which approach is likely to reap the most benefits? Although the social psychology and social practice perspectives have been constructed in recent debates as oppositional, theorists of both traditions have called for integration of the two approaches.

Kurz et al[8] suggest that it is perhaps at the intersections between theoretical approaches that the most novel and important policy intervention implications are likely to be found. The traditionally more individualistic approaches of social psychology can benefit from engagement with the more social models of social practice theory in which individual practices are inseparable from the material, procedural, and social structures that constitute them and the other practices to which they connect. This can helpfully focus attention on the role of policy and legislation in changing context rather than the role of persuasive communication in changing beliefs and attitudes. Notably, some strands of social psychological theorising have emerged that emphasize the importance of understanding environmentally relevant activities and policies in terms of socially constructed meanings. In addition, in line with social practice theorists' emphasis on the interlinked nature of behaviours, some social psychological research has recognised that habitual behaviours that might at first glance seem unrelated can cluster together.

[7] Pantzar, M. and Shove, E. (2010) 'Understanding innovation in practice: a discussion of the production and re-production of Nordic Walking', *Technology Analysis & Strategic Management* 22 (4): 447-461.
[8] Kurz,T., Gardner, B., Verlanken, B., Abraham, C *WIREs Clim Change* 2015, 6:113–128. doi: 10.1002/wcc.327

Social practice theory provides an appealing theoretical model of how practices evolve, are maintained, and might potentially change. However, its operationalisation into policy remains not yet material. Lessons can be learned from social psychology without requiring abandonment of the specific theoretical commitments that social practice theory entails.
Social practice theorists have borrowed ideas from science and technology studies in theorising around the role of material elements in the formation and circulation of social practice. A deeper and more wide-ranging engagement with the diverse theoretical, empirical, and epistemological approaches that constitute contemporary social psychological theory might offer similarly useful 'borrowings' for both the theorising and changing of the social meanings of practices.

4. Organisational change and low carbon & renewable technologies

4.1. Models and theories of organisational change

4.1.1. Complementarities theory

Any project/movement to create change toward low carbon takes place in a context that offers constraints and enablers. Contextual issues are those that lie outside the direct scope of the project or activity in question but which have a significant effect (typically a constraining effect) on its likelihood.
In 2000 American author Ken Wilber's integral theory[9] identified different aspects of reality according to whether they were internal or external, individual or collective.
David Ballard[10] developed this idea to create a comprehensive way of mapping contextual issues along two dimensions individual-collective and subjective-objective.
Complementarities theory shows how change is created when 'doing more of one thing increases the returns of doing more of another' or 'investing in one variable makes more profitable investing in another, setting off a potentially virtuous circle…' [11] Similarly the Limits to Growth analysis shows interacting layers of limits creating a vicious cycle.[12]

Contexts for change – Complementarities Matrix

[9] Wilber, K. (2000). A Theory of Everything: An integral vision for business, politics, science and spirituality. Boston: Gateway.
[10] Reason, P et al (2010). *Insider Voices: Human Dimensions of Low Carbon technology.* University of Bath
[11] Pettigrew et al (2004) Innovative Forms of Organizing: International perspectives, London: Sage
[12] Meadows et al (2004) Limits to Growth: the 30 year update.White River Junction,Vt: Chelsea Green

Quadrant 1. *Person* **Individual subjective factors** (Personal values, worldview, emotions, assumptions, etc)	**Quadrant 2.** *Job* **Individual objective factors** (Influence of one's role, skills, knowledge, relationship set, etc)
Quadrant 3. *Organisation* **Collective subjective factors** (Group cultures, shared mindsets, shared norms, etc)	**Quadrant 4.** *Sector* **Collective objective factors** (Political, economic, social, technological, legal, environmental)

Change is facilitated when an individual's sense of themselves as being ready to take action (Quadrant 1) and having relevant knowledge, skills and capacities (Quadrant 2) occurs alongside cultural impetus towards change (Quadrant 3) and an opportunity in the outside world (Quadrant 4). Complementarities theory suggests that at certain times, when all these contextual factors come together they create a window of opportunity when individuals and groups are likely to be able to act effectively for change.

The response to an opportunity for change in the world (quadrant 4) for example at the end of an investment cycle when industrial plant must be replaced and/or at times of major policy revision or the arrival of a new technology will depend partly on how it is perceived by individuals within an organisation (as an opportunity or a threat) and on their sense of agency and are able to grasp the opportunity (Q1), partly on their skills and knowledge including being able to engage others (Q2) and partly on the capacity of the organisational culture to support originality and risk taking.(Q3)
The most highly motivated individuals, even if they have a good idea, will be frustrated if their social context is fragmented and unsupportive (Q3) and if the opportunities in the real world are occluded or non-existent. This demonstrates the interplay between the 'hard' objective world of technology and the 'soft' world of individuals and human relationships.
Timeliness is key – the need to seize, create or adapt opportunities in the external environment and interpret them within the organisation. These windows of opportunity may be brief and so there is a need to build capacity in waiting so that opportunities can be responded to when they arise – this is agency at both an individual and collective level.

The following sections look at some of the contextual factors and the attendant theories at work within each quadrant of the matrix.

Contextual factors in Quadrant 1 –the person - individual subjective factors

Emotions - Given the gravity of the global environmental situation it would be surprising if people who engage with it did not experience significant emotions and this is often the case. 'Champions' have a huge emotional commitment to their work plus a tremendous commitment to turn that emotional energy into responses that can make a difference
The deep ecology view says that if an emotional connection with the work of environmental sustainability can be established, it is life transforming. Deep encounter (with the state of the world) does indeed tend to lead to deep questioning and in due course to deep commitment.

But while emotions are usually fully engaged by 'champions', such people are fairly rare exceptions. Processes of people avoiding difficult emotions such as these are well-documented by researchers in the field of environmental sustainability.
Processes of repression are well explained by practitioner-theorists such as Joanna Macy[13]. Basically, most people understand quite well that it would be distressing for them to go too deeply into environmental sustainability. Providing them with more data only reinforces their defences. People are not stimulated to act, but are more likely paralysed, out of fear. She noted the greatest danger: apatheia, the deadening of the mind and heart; since response is so difficult, we can pull down the blinds and busy ourselves with other things.1
People may be repressed in a variety of ways. Psychologically they may fear any number of things; pain, despair, guilt, causing distress, being unpatriotic, appearing weak, powerlessness or they may distrust their own intelligence. But there are also socio-economic sources of repression such as mass media, job and time pressures and social violence. The consequences of such repression can include fragmentation and alienation, displacement activities, blaming and scapegoating, political passivity, avoidance of painful information, diminished intellectual performance and burnout and powerlessness.

Awareness - of what is happening and of what is required. There are 4 levels of awareness:
1. Awareness of the agenda
2. Awareness of scale, urgency and relevance
3. Awareness of the systemic structure of the issues (delays, interactions, feedback loops etc)
4. Awareness of the limits of human agency

These four levels of awareness are of increasing importance and appear to be of increasing difficulty to acquire. While it is clearly unrealistic to expect every person to have high levels of awareness, addressing the challenges of a low carbon world requires access to them all. For most people, the primary challenge seems to be developing awareness of scale, urgency and relevance.

Agency - or the ability to find a response that seems personally meaningful.
There is very strong evidence that promoting awareness does not stimulate behavioural change unless agency is developed in parallel. In developing agency, people may need to develop their role and acquire new skills.
The most significant agency is found in addressing the wider contextual issues, for instance by changing a law or by amending the public procurement process for major projects so that low carbon issues may be incorporated in the design.
Many people feel powerless when it comes to responding to environmental issues in a personally meaningful way, whilst those working for low carbon solutions often create their own sense of agency by identifying opportunities for action.

Association - with other people in groups and networks. On huge issues such as climate change, most things that are ‘meaningful’ are very difficult unless we do them with others. Association with other people can support wavering willpower and can bring a variety of perspectives to an issue and so lead to better decisions
Such association is likely to reinforce a sense of agency, since it is more likely to offer validating feedback on pro-environmental actions that might be seen as irrelevant by a more typical group.

[13] Macy, J. R., & Brown, M. Y. (1998). Coming Back to Life: Practices to reconnect our lives, our world. Gabriola Island: New Society Publishers.

For all these reasons, association is at the heart of work for low carbon and sustainable development.
Each of awareness, agency and association is necessary but insufficient in isolation, which means that change needs to work across all three. If there is association and awareness, but agency has not been developed, what is left will be little more than a talking shop. If there is association and the opportunity for agency, but the opportunity to develop awareness has not been taken, then actions will tend to miss the point and might even be trivial. If there is awareness and the opportunity for agency, but no association with a wider group, change agents will probably be ignored and almost certainly become increasingly stressed and resentful.
The ability to conceive of and hold higher purpose or creative visions – this is the notion that what we are trying to do must be valuable for its own sake and not just something that we want to do for other reasons. A huge higher purpose such as to build a thriving and resilient world that is fit for humans to live in and yet also within our planet's limits may be hard to express as a vision in every project.

Quadrant 2 – job - personal objective factors
Demographic factors – although there is little impact from socio- demographic factors such as age, gender, education or social class on environmental behaviour it is true to say that those whose circumstances enable them to pay attention to issues beyond day to day survival are likely to be more engaged.
Knowledge - (e.g. carbon offsetting) a lack of understanding of energy efficiency or low carbon issues and their significance can only hamper effective action. Developing knowledge of the issues within whatever work or societal role is being undertaken facilitates commitment to action.
Ability to maintain networks and coalitions – interpersonal skills that extend beyond the usual boundaries and the ability to work within the organisation formally
and informally (known as relational practice).

Contextual factors in Quadrant 3 – organisation - collective subjective factors
Cultural relationships – Cultural Theory says that there are a variety of worldviews that need to be respected in any social initiative. These include hierarchists (old fashioned, conservatism for example), egalitarian (civil groups such as the Greens), fatalists (could include the socially excluded) and individualists (detached and self-sufficient).

People may develop various **perspectives** throughout their lives. These perspectives are an important determinant for a person's perception of issues such as the greenhouse effect and global warming and therefore ultimately their attitude to energy use, renewables and carbon reduction. The *theory of perspectives* was developed by Professor John Adams at University College London.[14] These perspectives inform our collective assumptions about nature.
In 'nature capricious' (renewal), there are no rules, anything can happen. We cannot learn from experience, nature is a lottery so there is no point in worrying about it. This is the position of the excluded *Fatalists*; the theory claims that this myth will not be found in policy-making or other circles.
In 'nature benign' (creative possibility), the ball is in a forgiving landscape, whatever we do, an 'invisible hand' brings it back to the optimum position. We can afford to take risks because nature will forgive. This is the position of the market-oriented *Individualists*; the theory claims that this will be the myth of business people.
In 'nature ephemeral' (creative destruction), the position is precarious, once a small amount of resistance is overcome, any move will be for the worse, great caution is needed in our interactions

[14] http://www.lenntech.com/greenhouse-effect/global-warming-perspectives.htm#ixzz1VacrkAf5

with nature. This is the position of the communally-minded *Egalitarians*; the theory claims that this will be the myth in NGO circles.
In 'nature perverse / tolerant' (conservation), nature is only benign within defined limit; outside these limits, chaos will reign. Properly qualified and duly appointed experts are needed to advise on where the limits are so that they can be avoided. This is the position of the rule-oriented *Hierarchists*; the theory claims that it will dominate in governmental and other bureaucracies.

The view of nature and the perception types mentioned above determine a person's **world view** including their vision of the relationship between people and the environment. This relationship can be perceived in three different ways; as anthropocentric, as ecocentric and as partnership.
Anthropocentrism considers nature merely as something providing resources which are there to be exploited. Everything in nature is valued in terms of benefits to humans. No limits to growth exist and people have unlimited faith in technological possibilities. The fundamental attitude towards nature is *supremacy*. This view is usually adopted by individualists, which are *risk-seeking*.
Ecocentrism considers nature to have its own aims. If humans are not involved these aims will continue to exist. Nature is defined as a complex whole which organizes itself. Humans are seen as being part of nature. The fundamental attitude towards nature is *participation*. This view is usually adopted by egalitarians, which are *risk aversive*.
Partnership is a less extreme attitude towards the relationship between people and nature. The earth is viewed as a totality, where human and nature have equal value. Mutual dependency between people and nature is stressed. The fundamental attitude towards nature is cooperation, or *balance*. This view is usually adopted by hierarchists, which are *risk accepting*.

These three perceptions create different attitudes towards risk and combined with whether a person is an individualist, an egalitarian or a hierarchist will have a major impact on his or her perception of the issue of climate change and therefore influence their attitude towards carbon reduction.

Organisation Development Stage - **Six levels of response**
Built to inform organisational responses to climate change, this model outlines how organisations can improve their response to in six predictable stages, becoming able to handle issues of increasing complexity as they understand the issue better and build their own capacity.
Response level one: Non-responsive
Senior managers see climate change as threatening and would prefer not to engage with it. There will be reluctant action, if any. No resources will be allocated. Most businesses have moved beyond this stage.
Response level two: Compliant
Managers will respond to pressure from legislation or customers but won't be proactive. There is little understanding of climate change issues and how they apply to the organisation's activities, and actions risk being a tick-box exercise. Many organisations are responding to changing needs of major stakeholders, so avoiding costly emergency actions to comply under duress.
Response level three: Efficient management
Managers recognise that climate change needs to be managed systematically, rather than occasionally. There will be measurement systems and targets, ISO 14001, carbon management, etc. Climate change and carbon are usually delegated to someone lower down the organisation; senior managers may think they've cracked it. Work at this level does provide a foundation for later progress. But relatively few, even at a senior level, yet grasp the scale of the climate change challenge, especially for adaptation. Many organisations are beginning work at this stage.

Work at levels one to three represents business-as-usual management. But climate change is certainly not a business-as-usual issue. We know for sure that the future will not be like the past: procedures and ways of working that were good enough then will not be good enough in the future. This is a strategic issue, challenging the basics of organisational functioning. It needs the strategic perspective of the boardroom to be involved, building on and interacting with the strong operational grip of the agenda that begins to be developed at level three.

Relatively few organisations (in either public or private sector) have yet made the transition to the boardroom or senior officer or elected member teams that is facilitated at level four and which is required for effectiveness at levels five and six.

Response level four: Breakthrough projects

Top managers begin to set targets for significant performance breakthroughs, reaching beyond the status quo and requiring a search for altogether new approaches. These projects allow participants to explore issues in depth, building a base of understanding of issues and options from which leaders can responsibly set the organisation's future direction. Focusing on areas where win-wins with the organisation's other priorities are possible, such projects potentially offers multiple benefits e.g. costs, revenues, relations with stakeholders and reputation. Recognising and using response level four represents the current challenge for many programmes.

Response level five: Strategic resilience

Top management teams recognise that climate change is of significant strategic importance. They are active on the issue as a key part of strategic management, ensuring every aspect of the organisation (capital, plant, facilities, services) and its wider systems are resilient to climate impacts and an energy-constrained future. Serious climate change responses need an ability to work at this level, which is still rare.

Response level six: The champion organisation

At this level, still very rare, the organisation's focus is on significantly influencing the political, social, legal and technological environments in which it operates in order to promote sustainability, rather than just respond to a changing climate. Very few organisations yet work consistently at this level.

While increasing capacity can be shown to significantly help wider social responses to climate change, not all organisations have an equally compelling business case to reach the higher response levels. However, organisations that take big money decisions that are semi-irreversible over a 20+ year timescale, those with a strategic role, or which hold significant assets, usually have a business need to activate response level five, alone or with others. For most, this remains quite a challenge. For many it is not even recognised as a challenge.

Contextual factors in Quadrant 4 –the system –collective objective factors

The PESTLE mnemonic that is used in corporate strategy processes to map wider contextual changes: political, economic, social, technical, legal and environmental factors is at work here. How does infrastructure support or block change other than at the most general level, still less do they explore when it does, or doesn't.

The vital role of infrastructure and its replacement - Human 'agency' is not constant but is closely linked to infrastructure changes and to the replacement of infrastructure. Catch one of those moments and 'agency' is objectively greater: there is genuinely more that one can do. Miss one, and our ability either to reduce costs, or to reduce carbon emissions, is radically reduced in this specific area, very often for decades. It never goes away altogether, but things become a great deal harder. Examples include:

- Kerbside collection and recycling
- Food system: chilled and frozen foods; food miles
- Replacement of heating equipment at home
- Oil shale/nuclear power vs renewables

Systems delays - Quite apart from the delay inherent in the infrastructure itself, potential choices in response to environmental issues are often only available after a significant time delay. Technological choices (e.g. nuclear power, or the construction of a new building) are typically only possible after a lengthy time delay, which includes assessment time, planning, public debate, raising of funds, construction and bedding-in. These delays can be affected by policymakers and others to some extent, but not altogether. They have a big effect on systems behaviour and on the feasibility of certain options

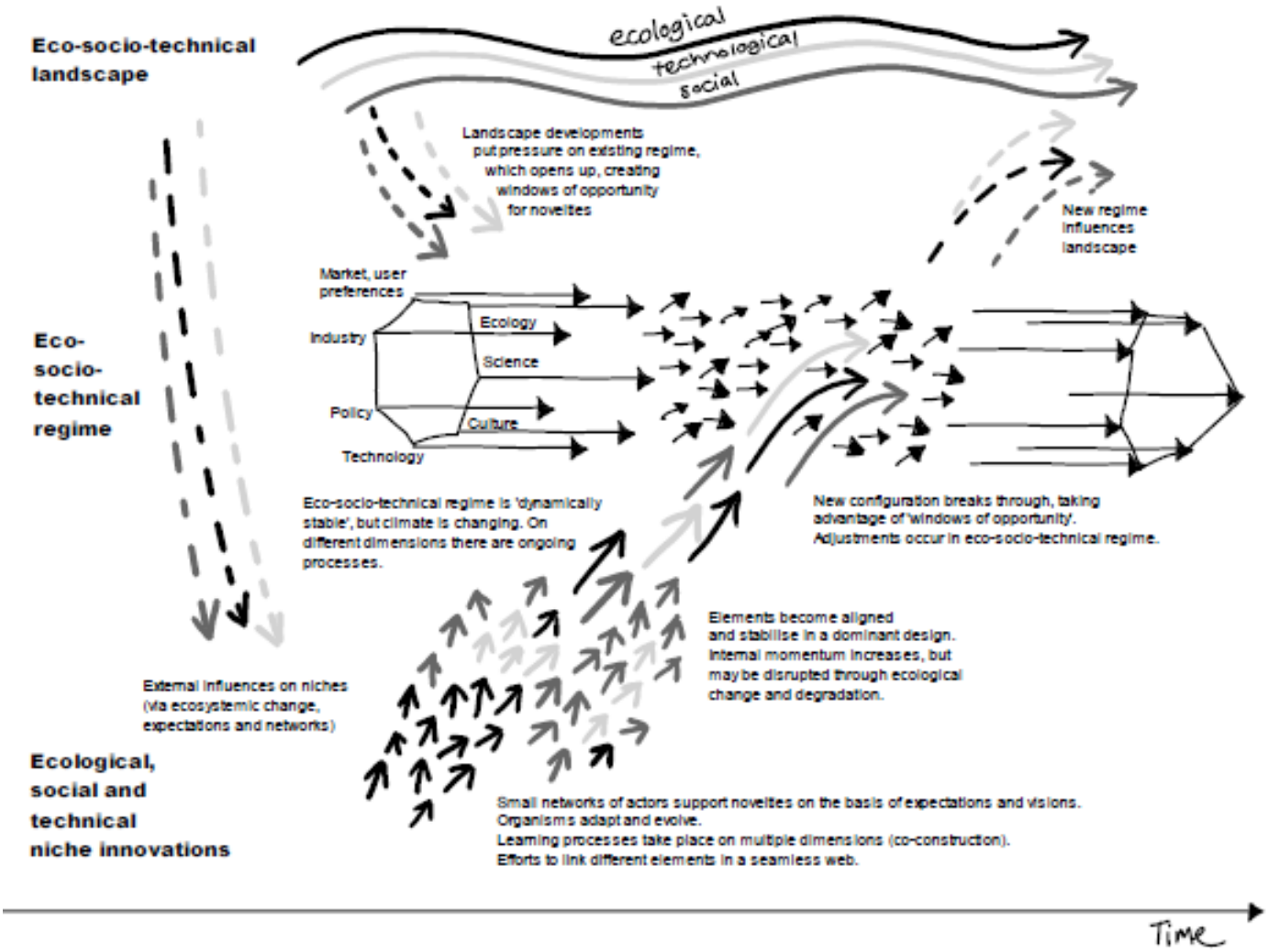
Changing costs structures for replacement infrastructure - The experience curve means that costs move down sharply when growth is rapid: doubling from 1,000 to 2,000 cumulative units of production (in an industry) is much quicker than doubling from 20 million to 40 million units. This means that costs respond quickly to early growth and that the choice between technologies and the relative cost position of firms within an industry is tremendously affected by early buying decisions. Basically, a technology, or a firm, that moves quickly down the experience curve can develop robust cost advantages.
The effect of this in terms of environmental choices is clear: the relative costs of decisions taken in the future depends on choices made by people today, when the costs (but perhaps also the potential benefits) are much greater. It is not cost effective to buy PV cells to generate electricity now, but an energetic investment process can potentially radically change costs.

The social process of shaping technology - The theories aim to go beyond what is sometimes seen as a technological determinist worldview, where technology is introduced in a linear fashion, with technological change being an exogenous factor introduced into social situations which are then affected by it.
Socio technical regimes[15] are the relatively enduring and stable pattern of interactions: cognitive routines, regulations and standards, adaptations of lifestyle to technical systems, sunk investments in machines, infrastructures, and competencies. They take place at the level of organisational fields and create a lock-in to existing patterns. Recent work emphasises in addition the importance of the co-evolution of institutions with sociotechnical regimes

Technological niche - the "micro-level where radical novelties emerge. These novelties are initially unstable sociotechnical configurations with low performance, [they] act as 'incubation rooms'. Niche-innovations are carried and developed by small networks of dedicated actors, often outsiders of fringe actors; both niches and regimes have the character of organisational fields (community of interacting groups).

[15] Geels, F. W., & Schot, J. (2007). Typology of Sociotechnical Transition Pathways. Research Policy, 36, 399–417.

Sociotechnical regime



For regimes, the communities are large and stable, while for niches they are small and unstable. Both niche and regime communities share certain rules that coordinate action. For regimes, these rules are stable and well-articulated; for niche innovations, they are unstable and 'in the making'. In addition, the social dimensions of what Geels et al usually refer to as technological niches: issues of capacities for collaboration, cohesions, agency, purpose are also important aspects of the model.

Sociotechnical landscape - an exogenous environment beyond the direct influence of niche and regime actors (macro-economics, deep cultural patterns, macro-political developments). Changes at this level take place slowly (decades)", although have a dynamic quality. However this notion of landscape is limited because it is described as a human construct or paradigm. In reality, the landscape must include the 'real' planetary landscape particularly when the planetary ecology is under considerable damaging stress. As such changes in the landscape may at times be discontinuous and therefore sudden rather than taking place slowly as Geels suggests.
The multi-level perspective argues that transitions come about through interactions between processes at three levels:

a) niche-innovations build up internal momentum, through learning processes, price-performance improvements, and support from powerful groups,
b) changes in the landscape level create pressures on the regime and
c) destabilisation of the regime creates windows of opportunity for niche-innovations.
The alignment of these processes enables the breakthrough of novelties in mainstream markets where they compete with the existing regime.

Laws - Laws lock thinking at a particular moment into a future where that thinking may no longer have any validity. They may constrain or enable behavioural responses. For instance, World Trade rules increasingly discourage state support for emerging industries.

The limited availability of current flows of energy and capital - Research by the Tyndall Centre suggests that it is still possible in principle to build a low carbon economy in the UK. However there will need to be economic activity and a flow of energy for this to be possible
The problem is that economic activity is dependent on use of fossil fuels to an extent that is rarely appreciated. It doesn't take much of an interruption to the flow of energy from oil to have a major impact on economic activity and in due course on other forms of production, including that of capital stock.

A landscape of agency-filled but brief events - This leads us to suggest that effective action for sustainability depends on seizing, or creating, moments when agency is available. Agency is not just a personal construct or a social construct, but occurs at the intersection of individual awareness, effective association, and objective if fleeting phenomena that provide opportunities that may not be there for long (Quadrant 4).

4.1.2. Complementarities matrix as a research tool

The complementarities matrix has been successfully used to analyse and inform change in a number of organisations representing many sectors, most significantly in 2011 as part of the Improving Cold store Equipment in Europe (ICE-E) project, funded by the EU through Intelligent Energy Europe, which worked with cold stores across the EU. Part of the project's remit was to examine the non-technical barriers and enablers to the uptake of energy efficiency measures in the cold store sector.
During the ICE-E project ten non-technical audits were conducted with cold store operators. In each case the cold store operators and, where possible, a selection of their staff were interviewed on site over time in order to discuss and determine the non-technical issues and conditions, which were either forming a barrier to energy efficiency practices or conversely, were actively helping to promote good energy efficiency practice within the cold stores.

The interviews used the complementarities matrix as a framework to gather information and experience and also to promote further discussions and actions. It provided a template on which to map and understand the contexts for the cold store operators.

Person	Job
Individual subjective factors Personal values, worldview, assumptions	*Individual objective factors* Role, skills, knowledge, experience, relationships
Company	**Sector**
Collective subjective factors Group cultures, shared mindsets, shared norms	*Collective objective factors* Political, economic, social, technological, legal, environmental

The theoretical basis of the matrix broadly categorised non-technical issues under four main areas

- Individual subjective factors - related to the individual person
- Individual objective factors - job related
- Collective subjective factors - related to company culture
- Collective objective factors - related to external market sector, regulatory and economic forces

The theory behind the complementarities matrix says that doing more of one thing increases the returns of doing more of another or, applied to the workings of an organisation, investing in one variable makes it more profitable investing in another, setting off a 'virtuous circle of high performance.' The example below outlines the key issues identified in one UK cold store operator and distribution business. In this case although a number of the identified contextual factors are supporting the drive towards low carbon, others are hindering. As a result there is currently no 'virtuous circle' of interrelationships.

Complementarities matrix	
Using the complementarities matrix it is possible to highlight some of the contextual factors at work in the narrative of this company. Although there are a number of individual low carbon proponents and activities and some who carry broader responsibilities for delivering environmental efficiencies, there is no overarching 'virtuous circle' of interrelationships between quadrants, rather there are both conflicting pressures and isolation of key actors against a backdrop of volatile market supply and demand and inadequate capital funding.	
Quadrant 1 Person **Individual subjective factors** Existence of environmental and carbon 'Champions' at senior level in temperature controlled and distribution parts of business.	**Quadrant 2 Job** **Individual objective factors** Collaboration activities delivering lower carbon – but not systematically measured. Significant energy efficient practices being introduced at operational level.
Quadrant 3 Organisation **Collective subjective factors** Existence of group environmental strategy co- authored by Group Environmental Manager and board member. Carbon inefficient company practices eg contractual arrangements, moving in the right direction but remain limiting Capital spend restrictions	**Quadrant 4 System** **Collective objective factors** Intermittent supply chain pressure/encouragement to reduce carbon in tier one supplier parts of business (principally distribution) encouraging ongoing development of distribution platforms and inter-company collaborations.

Volatility in the supply and demand for chilled and frozen food storage capacity Isolated positioning of Group Environmental Manager in company structure	Supply chain induced increases in carbon emissions in tier two and three supplier parts of business (principally chilled food storage) eg through demand for lower freeze temperatures and increased tempering Regulatory landscape changes forcing carbon reduction (eg banning of R22 refrigerant). Company is active member of Food Storage and Distribution Federation and involved in industry sector level consultations with Westminster and Brussels eg on phasing in of R22.

All the conversations were analysed and reflected back into the organisation along with the identification of how different issues may be contributing to the delivery of good or bad energy efficiency practice.

Where appropriate, recommendations were made for actions that could be taken to increase energy efficiency awareness, influence attitudes to energy efficiency or change energy efficiency related practices. The feedback also acknowledged and noted where cultural or external, sector-wide, forces were at play.

The key findings from all ten stores were amalgamated and a thematic analysis was undertaken identifying the enabling conditions under each quadrant of the matrix that could contribute to a virtuous circle of performance in energy efficiency and carbon reduction (see below). This complemented the results and outcomes from the technical strands of the project, with the aim of helping to inform, motivate and enable cold store operators to attend to non-technical issues and create positive change for more energy efficient working.

Thematic analysis of case study conversations using the complementarities matrix

Person **Awareness** held at a personal level of energy efficiency issues both at home and at work. **Attitude** that energy efficiency is important, and not only because it saves money. Product quality and safety and energy efficiency are linked. **Agency** - individuals feel willing and able to make suggestions and to have a positive influence on energy efficiency. **Action** for energy efficiency is incentivised and normalised; part of the company's DNA.	***Job*** **Communication** - energy efficiency relates to each role through simple connections to job specifications. Incorporated into induction training, on the job training, specialist training and into maintenance contracts. **Targets** – energy efficiency KPIs created for all posts. Results measured, monitored and rewarded. Bonus schemes based on energy/ tonne of throughput or productivity or similar and designed to overcome any cultural barriers. **Change agents** and energy efficiency champions are nurtured and supported.
Company **Enabling culture** encourages workers to innovate, instigate bigger energy efficiency wins, optimise equipment and share information top down and bottom up.	***Sector*** **Best practice** shared within sector (including clients) and economies of scale realised through joint working. Sector wide partnerships facilitate joint energy efficiency

Energy policy for efficiency and green energy generation drives delivery of cost reduction and energy security benefits. **Standards** – Company is benchmarked for energy efficiency and adopts energy management standards incorporating continual improvement and measuring and monitoring methodologies. **Energy efficiency credentials** are shared with customers and other stakeholders and used to retain and grow customer base and maintain competitive edge. **Investment** – realistic payback terms adopted and innovative approaches developed for funding of energy efficiency projects.	and renewable energy investment and project opportunities. **Influence** of sector agenda through development of relationships with key sector associations and stakeholders including refrigeration equipment manufacturers and installers. **Opportunities** offered by emerging local, regional or national Government schemes anticipated, cultivated and taken up.

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