# HOW BEHAVIOUR CHANGE WILL UNLOCK NET-ZERO

THE UK'S NET-ZERO TARGET IS AT RISK WITHOUT A SUBSTANTIAL AND SUSTAINABLE CHANGE IN CORPORATE AND PUBLIC BEHAVIOUR

AN ENERGY RESEARCH PARTNERSHIP REPORT

MARCH 2021

OPPORTUNITY Education *Availability*
Pressure PERFORMANCE Fear Wealth
CAPABILITY Duty *Value* Social *Behaviour*
Knowledge *Responsibility* LIFESTYLE
Happiness SATISFACTION FEAR Wealth *Financial* SOCIAL
Opportunity *Motivation* Competitiveness
AVAILABILITY *Lifestyle* Financial *Change* HABIT *Fear*
CHANGE Evidence Attitude
Pride *Satisfaction* WEALTH Capability
MOTIVATION Lifestyle Information
Habit Status Pride
VALUE Pressure Responsibility Duty SOCIETY
STATUS *Competitiveness* ACCESSIBILITY Value
Attitude Pride Opportunity
Duty INFORMATION FEAR
Education Habit RESPONSIBILITY
Wealth PRESSURE Social Behaviour
Society Capability Society
FINANCIAL *Status* HAPPINESS Change
ANXIETY EVIDENCE *Accessibility* Status
*Behaviour* DUTY *Evidence* Anxiety
Performance Satisfaction KNOWLEDGE
Information PRIDE ATTITUDE *Happiness*
Education BEHAVIOUR Knowledge SOCIAL
Motivation *Performance* Social. EVIDENCE
*Financial* ATTITUDE Behaviour *Habit*
Knowledge Wealth
VALUE *Society* COMPETITIVENESS *Duty* CHANGE
*Capability* Pride *Lifestyle* Education

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# 1. EXECUTIVE SUMMARY

The energy sector has reduced its **CO₂ emissions by 63% since 1990** through the reduction of coal-fired generation and by increasing renewable energy capacity. However, there is evidence that the Government is not doing enough to reduce $CO_2$ emissions from domestic and commercial consumers. Of the 25 critical actions for reducing emissions recommended to Government by the Climate Change Committee (CCC) for the year 2018-19[1], only one was delivered in full. **The next steps towards Net-Zero will require public engagement and significant change in behaviour.**

"Over 40% of the abatement in our scenarios to 2035 involve at least some degree of change from consumers (e.g. driving an electric car or installing a heat pump instead of a gas boiler).

Over 15% of the abatement measures in our scenarios require consumer choices – both to reduce demand and improve efficiency. Shifting quickly towards healthier diets, reducing growth in aviation demand and choosing products that last longer and therefore improve resource efficiency are all key."
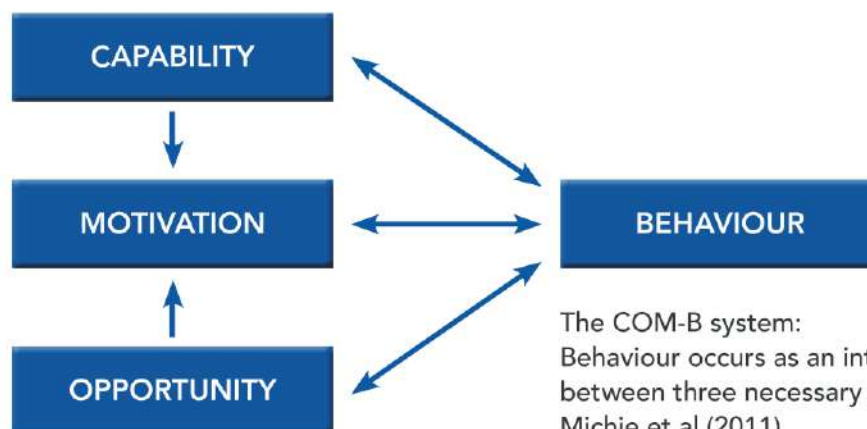
CCC Sixth Carbon Budget (page 70)

The Covid-19 pandemic has proved that decisive intervention by the Government can achieve significant shifts in behaviour. Although this was an unprecedented event resulting in serious consequences for those affected, penalties and financial support were still required to ensure people followed the rules. By comparison, the effects of climate change do not currently affect most people's daily lives. So, changing behaviour to embrace a Net-Zero lifestyle will require a cultural revolution of information-driven decision making, visible peer pressure and strong Government policies.

**Reductions in carbon emissions required to hit the UK's 2050 Net-Zero target will only be achieved if there is a substantial and sustainable change in behaviour across society.**

Change should be enabled through increased use of digitally derived insights in the home and at work, together with motivation through multiple channels. Interventions will be required in the form of education, incentives and affordable low-carbon alternatives. Sustaining this change will require both policies and proven technologies.

**If people are to change their carbon-emitting habits and behaviours, it is critical to identify solutions enabling capability, motivation and opportunity.**



The COM-B system:
Behaviour occurs as an interaction between three necessary conditions.
Michie et al (2011)

Figure 1 shows typical barriers, enablers, interventions and policies likely to impact a person's motivation to change behaviour towards a greener, low-carbon lifestyle. **When considering substantial changes which will affect people's daily lives, policy makers, service providers and manufacturers must consider public acceptance and a realistic timeframe for people to change behaviour and accept the 'new normal.'**

| GENERAL PUBLIC BEHAVIOUR CHANGE | CAPABILITY | MOTIVATION | OPPORTUNITY |
|---|---|---|---|
| **BARRIERS** | • Unable to access green energy in the local area.<br>• The cost to change to Zero-Carbon is too high.<br>• The location is not suitable for an electric car. | • Unaware of how climate change will affect them therefore reluctant to change behaviour.<br>• Satisfied with current travel arrangements and method of home heating.<br>• No peer pressure from neighbours. | • Older homes with poor insulation are not cost effective to change to electric heating.<br>• There is a limited number of car charging points in rural areas. |
| **ENABLERS** | • Regional green energy hubs.<br>• Increased operating range for electric and hybrid vehicles.<br>• Easy access digital aids for home heating and lighting. | • Compelling financial support programmes.<br>• Increased and visible increase in social responsibility.<br>• Low-carbon reward schemes. | • Upgrading social housing with improved insulation, low energy appliances and low carbon heating.<br>• Subsidised mortgage interest rates for heating and insulation upgrades. |
| **INTERVENTIONS** | • Reduce the options and choices for people to buy GHG emitting products and services.<br>• Lifestyle adapting smart technology. | • Mortgages linked to carbon footprint of homes.<br>• Local area emissions data published on a regular basis. | • New housing developments to be carbon neutral.<br>• Fossil fuel heating system scrappage scheme (public/ private funded). |
| **POLICY** | • Carbon taxation must be based upon affordability.<br>• Tiered vehicle scrappage scheme weighted in favour of essential car users and the lower paid. | • Increased levels of taxation on all fossil fuels.<br>• Residential carbon credit scheme. | • Heating and insulation grants.<br>• Government loan schemes for heating and insulation upgrades. |

Figure 1

Figure 2 shows the challenges the business sector (service and manufacturing) will face in moving towards a Net-Zero economy. Following the effects of the Covid-19 pandemic, meeting the 2050 target will require substantial investment by the business sector – in addition to the planned reductions in emissions for the energy generation sector. **This business sector must service changes in market demand due to behaviour change within the UK population. This will ensure there is not a relapse to carbon-emitting lifestyles due to lack of availability.**

| CORPORATE BEHAVIOUR CHANGE | CAPABILITY | MOTIVATION | OPPORTUNITY |
|---|---|---|---|
| BARRIERS | • The cost of implementing low carbon technology.<br>• There is no evident competitive advantage for 'going green.' | • No legislation forcing a change to green energy use.<br>• Recovery from the financial impact of the Covid-19 pandemic. | • What are the business incentives for implementing greener processes?<br>• Investors will not fund a low-carbon strategy without a clear return on investment. |
| ENABLERS | • Data capture for energy use, employee behaviour and transportation of goods.<br>• Energy and Net-Zero core teams trained and qualified. | • Consumers demanding goods produced with a small carbon footprint.<br>• Higher cost of goods and services with a larger carbon footprint. | • New technology available at a value based cost.<br>• Easy access to greener alternatives.<br>• Market changes due to Covid-19. |
| INTERVENTIONS | • Education and training with industry recognised qualifications.<br>• Centralised database showing carbon footprint of goods and services. | • Business Forums focussed on lowering GHG emissions.<br>• Business certification scheme (such as ISO) for greener businesses. | • Supplier selection to include carbon footprint data and certification.<br>• Green business certification could lead to increased sales. |
| POLICY | • Flexible employment contracts allowing people to work from home and avoid commuting. | • Increased corporate taxation (carbon tax) for high polluting businesses where there is little evidence of improvement. | • Green certification programme. Level playing field for doing business in the UK. |

Figure 2

# 1.1 Report recommendations

- Behaviour change must be regarded as a critical element of future low-carbon policies, lifestyle choices, product development and infrastructure upgrades.

- A sophisticated mix of regulation, incentives, nudges and penalties will be needed to motivate customers and industry towards Net-Zero. To succeed, these must be preceded with robust planning to ensure they are accessible and deliverable[2].

- Policy-driven behaviour change must be preceded with enabling plans for business and the general public to move towards a low-carbon lifestyle.

- Carbon reduction must be data-driven – with data captured and presented to show consumers how their actions will impact their carbon footprint.

- Government funding for innovation is needed to enable manufacturers to reduce retail pricing rather than offering the consumer a 'switching bonus' such as a scrappage scheme.

- Smarter use of energy in homes must be facilitated by further improvements to the smart meter roll-out programme, ensuring that centralised data can be used to advise consumers.

- Indirect $CO_2$ emissions (such as water use, food choices, shopping habits) must be monitored to help consumers see and understand their entire carbon footprint.

- Energy consumption and carbon footprint information must be easily available to all age groups.

- Ambitious, target-driven policies must be implemented to drive and maintain behaviour change.

- Future programmes relating to Net-Zero must consider and address barriers to behaviour change across commercial and residential settings.

# 2. CONTEXT

Behaviour change by the general public is critical if the UK is to achieve Net-Zero by 2050 – now that energy generation, industry and business have achieved major reductions and there is a roadmap of progressive regulation steering industry and consumers (such as the ban on sale of ICE cars).

By reviewing recent work completed by academia and industry, and by using well proven methodology, this report identifies the barriers and enablers that will impact decision making within homes, business and political institutions, leading to **long-term and sustainable changes in behaviour.** The report identifies **how habit disrupters can drive positive behaviour change if barriers can be broken down and enablers embedded in society.** In particular, our report focusses on how these habit disrupters can drive low-carbon lifestyles if they are successfully

embedded in everyday life – with no expectations of 'promoting success or failure' or 'loss to current living standards' placed upon them.

**The latest digital technology is critical in this transition.** For example, there are over 5 billion mobile device users in the world – accounting for 57% of global internet traffic. Ubiquitous digital technology can help track emissions, and encourage behaviour change through approaches such as automation.

**Industries can support the behavioural shift by supplying energy using renewables and other sustainable methods.** $CO_2$ emissions from energy generation have already **reduced by over 60% resulting in a total emissions reduction of almost 44% since 1990 (Figures 3 & 4). In comparison, residential and transport now emits 41% of the total UK emissions**[3].

Figure 3: Total GHG Emissions of 796Mte in 1990



Other GHG
24.9%
198MtCO$_2$

Energy Supply
30.4%
242MtCO$_2$

Business
14.0%
112MtCO$_2$

Transport
15.7%
125MtCO$_2$

Residential
9.8%
78MtCO$_2$
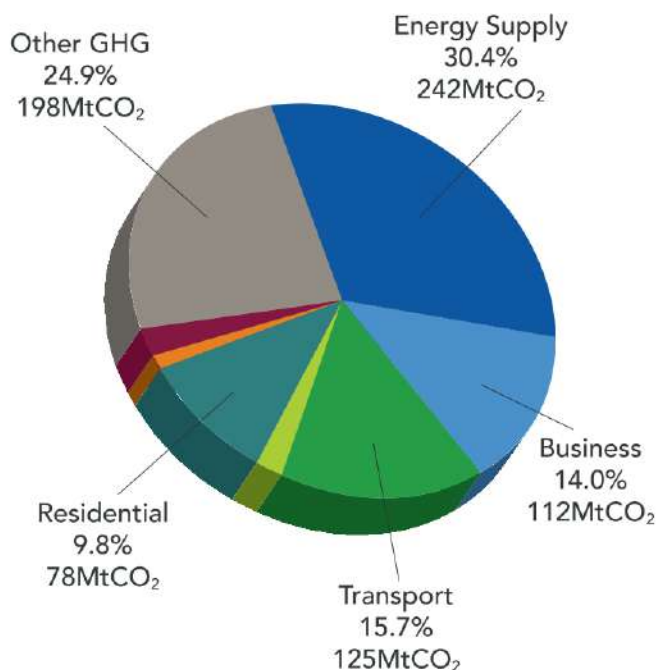
Figure 4: Total GHG Emissions of 447Mte in 2019



Other GHG
18.7%
84MtCO$_2$

Energy Supply
20.1%
90MtCO$_2$

Business
14.5%
65MtCO$_2$

Transport
26.8%
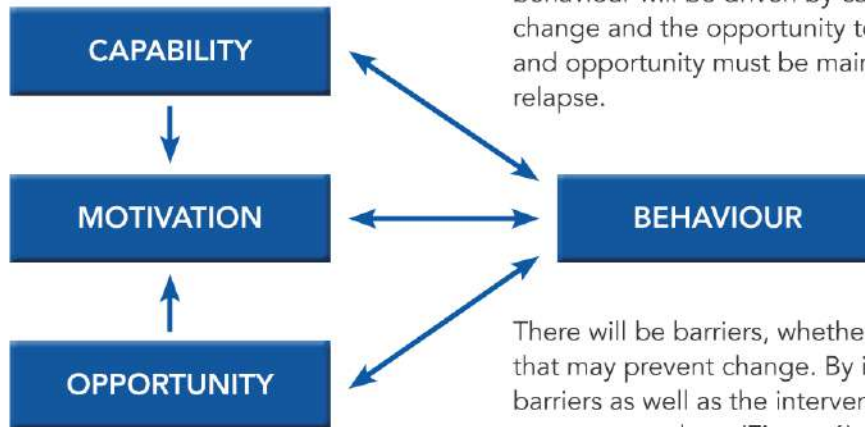120MtCO$_2$

Residential
14.6%
65MtCO$_2$
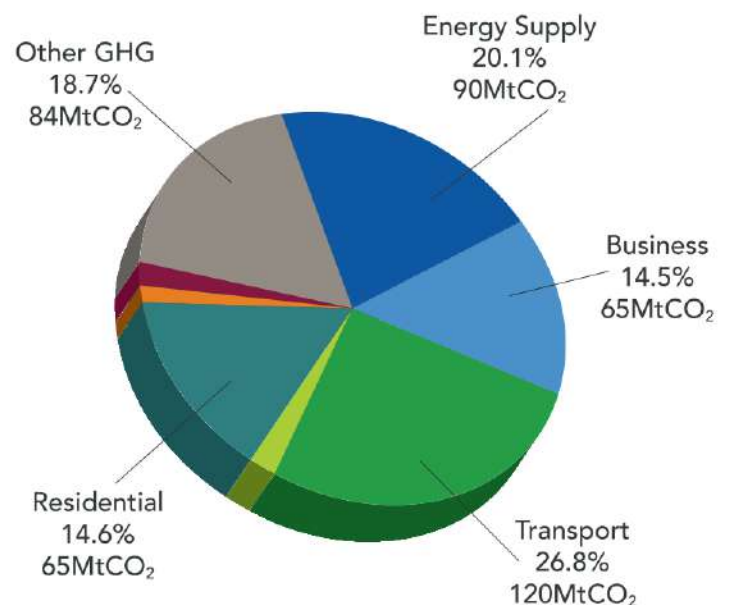
**The challenge now is for Government, industry and energy suppliers to influence the behaviour of the public towards a low-carbon lifestyle.**

# 3. BEHAVIOUR CHANGE MODELLING

The basic model used to illustrate the path towards behaviour change is the 'COM-B System for understanding behaviour' (Figure 5).
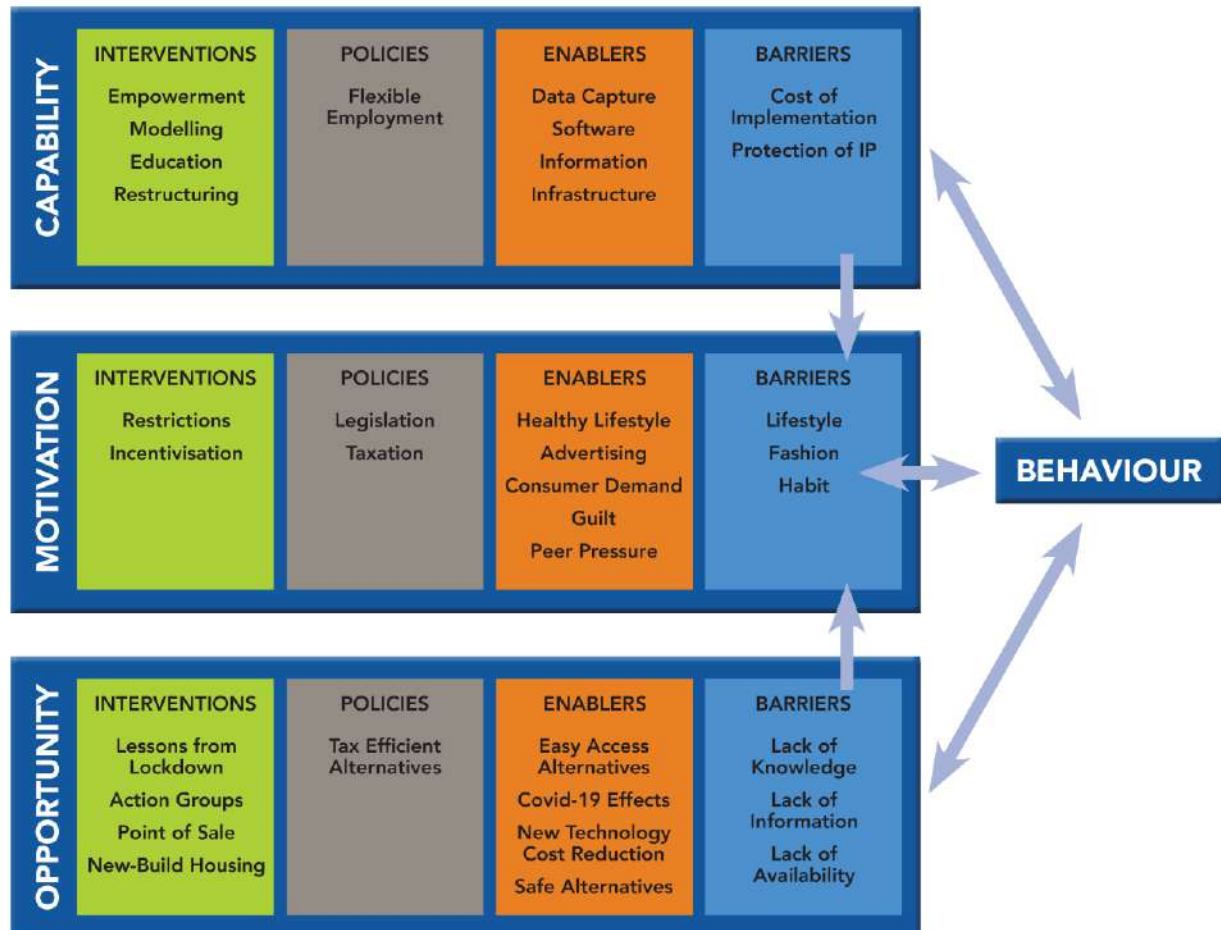
This identifies the three key thought processes the average person goes through when a change in behaviour is needed. Motivation to change behaviour will be driven by capability to make a change and the opportunity to change. Capability and opportunity must be maintained to avoid relapse.

Figure 5



There will be barriers, whether real or perceived, that may prevent change. By identifying these barriers as well as the interventions and enablers to overcome them (Figure 6), the three key thought processes can be mapped. Using this map, a structured plan can be developed that aligns Government, industry, business and the general public.

Figure 6



| | INTERVENTIONS | POLICIES | ENABLERS | BARRIERS |
|---|---|---|---|---|
| **CAPABILITY** | Empowerment Modelling Education Restructuring | Flexible Employment | Data Capture Software Information Infrastructure | Cost of Implementation Protection of IP |
| **MOTIVATION** | Restrictions Incentivisation | Legislation Taxation | Healthy Lifestyle Advertising Consumer Demand Guilt Peer Pressure | Lifestyle Fashion Habit |
| **OPPORTUNITY** | Lessons from Lockdown Action Groups Point of Sale New-Build Housing | Tax Efficient Alternatives | Easy Access Alternatives Covid-19 Effects New Technology Cost Reduction Safe Alternatives | Lack of Knowledge Lack of Information Lack of Availability |

Changes in behaviour will only impact carbon emissions once they are embedded in society. The initial changes in behaviour are likely to stem from habit disrupters. However, if long-term change is to be maintained, policies will be needed to prevent a behavioural relapse (Figure 7).
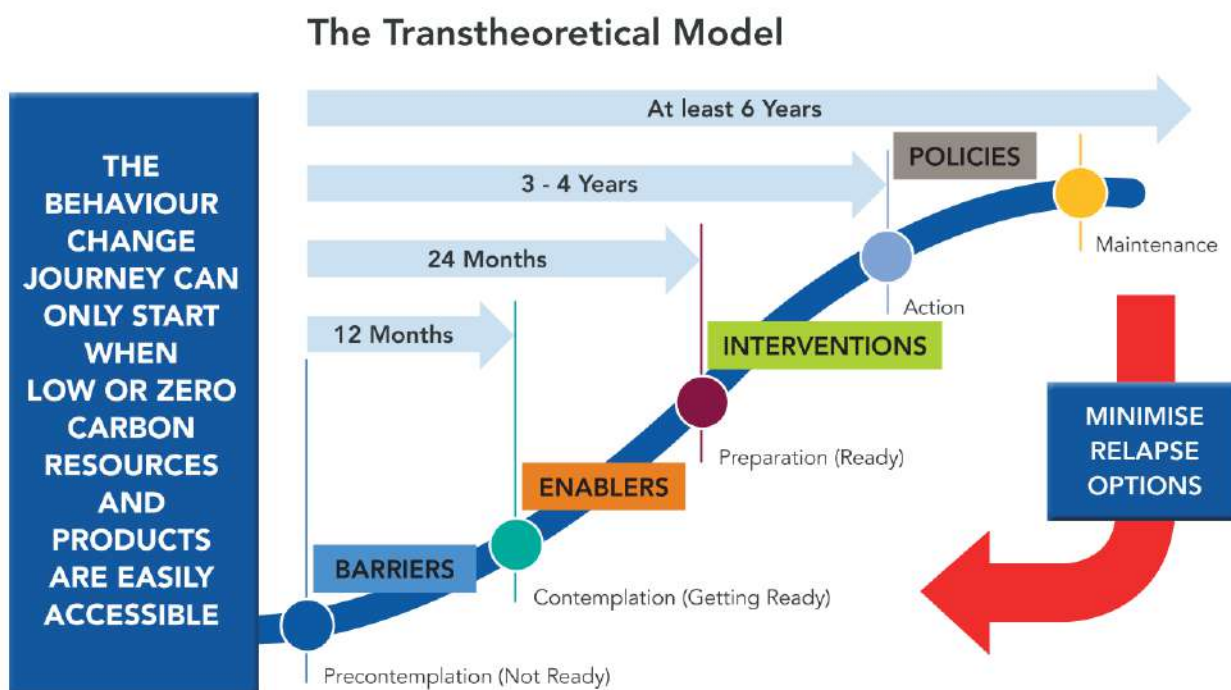
## The Transtheoretical Model



Figure 7

James O. Prochaska of the University of Rhode Island, and Carlo Di Clemente and colleagues developed the transtheoretical model beginning in 1977. It is based on analysis and use of different theories of psychotherapy, hence the name "transtheoretical".

Any new policies and interventions will need to be applied at all levels: manufacturing and construction through distribution and sales and finally the consumer. There is a case for Government incentives to be put in place to drive change (e.g. scrappage schemes). However, this will only drive up sales of 'green' products without incentivising manufacturers to innovate and reduce cost. **In addition, controls must be put in place to reduce or eliminate the potential for cheating the system by satisfying an 'outlawed' demand.**

### Innovation versus subsidy

Incentives for purchasing low- or zero-carbon technologies such as electric vehicles are needed to attract interest from consumers and encourage them to make a change. Other options could be to subsidise innovation-enabling cost-reduction of low-carbon products. A scheme such as an innovation fund could encourage manufacturers to develop low-cost products that would be accessible to essential users at a reasonable price, and still provide luxury options for those who can afford it.

### The need for tapered disincentives

There is a possibility that distributors might pre-register and stockpile petrol and diesel vehicles when the sale of new vehicles switches to hybrid and electric only. This would not be outlawed under current policies but would become less attractive through increased indirect taxation (i.e. Road Fund Licence and fuel-duty) affecting these vehicles. In a similar way, gas or oil-fired boilers could be sold on the open market as second-hand after the sale of new systems of this type is banned from 2025. A disincentive mechanism would be needed here as there is no tax on ownership of these products.

# 4. HABIT DISRUPTERS DRIVING BEHAVIOUR CHANGE

**Much of our behaviour is habitual – we follow unconscious routines triggered by contextual cues ('it's 8am, so it's time to drive to work') rather than making conscious choices ('which mode of transport would be best today?')**[4].

While habits help conserve cognitive resources, they also impede lifestyle change by 'locking in' behaviours. Many interventions (e.g. information campaigns) are ineffective because they are not strong enough to disrupt habits[5]. But since habits are cued by stable contexts such as particular times, places or social groups, changes in context will disrupt habits[6].

Moments of change – defined as 'occasions where the circumstances of an individual's life change considerably within a relatively short timeframe'[7] – are one of the most important levers for lifestyle change[8]. Research shows that disruptions – whether concerning a person's life-course (e.g. moving home) or structural (e.g. an economic downturn, extreme weather events) – provide opportunities to change behaviours[9], for example shifting from commuting by car to home-working[10].

This is why **interventions targeted to moments of change are more effective.**[11] Several studies show that mobility interventions are more effective when targeted to relocation[12]. One German study found that tailored public transport information and a one-day free transit pass were only effective when given to people who had recently moved house (increasing bus use from 18% to 47%), and did not change behaviour for those not relocating.[13]

Low-carbon behaviours such as energy efficiency and waste-reduction have also been more effectively encouraged using low-cost interventions in the 12 weeks following relocation[14] as well as at other moments of change, such as buying an electric vehicle[15].

Other opportunities to intervene include temporal milestones (e.g. New Year, becoming an adult), having a child, retiring, infrastructure disruption such as road closures, and, of course, Covid-19.

Covid-19 may be the most significant disruption to lifestyles since the Second World War. **People are working, consuming and interacting in new ways, some of which are more desirable both personally and environmentally.**

For example, one UK study[16] found that during lockdown:

- Online food shopping more than doubled from 12% to 25%.
- Food waste reduced from 24% to 14% through more waste-reducing practices (e.g. meal planning, freezing and preserving food).
- Consumption of energy and goods fell, especially for clothes and footwear (63% spent £0 in March – May 2020, versus 9% in Dec 2019 – Feb 2021).
- Working entirely from home rose from 11% to 36%.
- Most people who worked from home found it a positive experience.

**A significant proportion (31%) said they intend to increase the amount they work from home compared to pre-lockdown once restrictions are removed. Even more (41%) want to have more online work meetings, to socialise more online (43%), to have more online GP appointments (48%), and to fly less on holidays (47%). However, most (52%) also intended to use public transport less after lockdown.**

Of course, intentions do not always translate into behaviour change[17]. Since new habits take 2-3 months to form[18], the lockdown period in most countries is long enough to establish new, enduring routines. However, when the lockdown is lifted, there is a risk of recidivism into pre-existing habits[19], particularly if economic stimulus measures promote unfettered, high-carbon consumption. So, while Covid-19 may represent a unique window of opportunity to promote low-carbon lifestyles, this is only likely to occur if the infrastructure, incentives, and norms to encourage and lock in new low-carbon routines are in place. Fortunately, there is strong public support for Net-Zero policies (e.g. shifting to low-carbon transport, reducing red meat consumption) and a green recovery[16,20]. This provides a mandate for policy-makers to take bold measures to establish and lock in low-carbon habits.

# 5. THE ROLE OF DIGITAL ENABLERS

Digital technology and data have changed the way we live. From exercise to retail, innovations big and small have encouraged new behaviours. Digital enablers can help with behaviour change for Net-Zero too.

# 5.1 Emissions tracking

Understanding the GHG emissions related to an activity or product is extremely challenging. Modern supply chains are often global, involving many companies that provide raw materials, components or services that contribute to the final product. **Accurately assessing the impact of every step in the supply chain and correctly attributing this to the final product is highly complex.**

Currently accepted GHG measuring standards rely on a repository of pre-calculated 'typical' values which provide a good estimate of GHG emissions without assessing an entire supply chain back to raw products. This approach has real value in helping organisations understand their impact and helps to standardise the assumptions, but it requires skilled practitioners to ensure that the techniques are applied correctly, and adjustments made in a fair way.

For individuals, available tools often use simple lifestyle factors to provide an indicative view of emissions rather than an accurate analysis. While these can be interesting, they are vulnerable to self-reporting errors and omit many areas of GHG emissions.

**GHG emission estimates based on typical values can oversimplify the issues. This risks demonising certain products and services**

**rather than incentivising innovation and efficiency that will reduce emissions.** For example, beef has been identified as one of the most carbon-intensive foods[21]. However, recent innovations in seaweed-derived cattle feeds could substantially reduce the emissions associated with beef[22]. **If an average value for beef is used in carbon calculators it will be difficult for producers who adopt this practice to differentiate their product.**

There are alternative approaches which could be of value. Alongside advances in supply chain digitalisation, there are efforts to make GHG tracking more digital and data driven. One such example is The Open Group's Open Footprint forum.[23]

**Climate Trace[24] is another collaborative initiative which aims to take a more automated approach to tracking global GHG emissions.** The group aims to monitor 'human-caused' GHG emissions using cutting-edge technologies such as artificial intelligence, machine learning, and satellite image processing.

The move towards more granular and timely climate change data will enable organisations and individuals to **understand the true climate impact of their actions** and shorten the feedback loop between innovation, behaviour change and measured impact.

# 5.2 Behaviour change

Improved emissions tracking on its own is of little use; the value is realised through action such as behaviour change. Given the high levels of public support for decarbonisation and Net-Zero it would be understandable to assume that people would adapt their behaviour after seeing the impact of their actions on GHG emissions. However, this is not always the case.

One study provided individuals with feedback on their overall carbon footprint and measured both their initial reaction and long-term behaviour change. **It found that although people reported initial feelings of guilt if they were worse than average, this did not result in long-term behaviour change**[25]. Similar results have come from studies considering the motivational impact of fitness trackers which count steps or activity. For some, these devices or apps can provide motivation to exercise, but this is not correlated with an improvement in health outcomes[26].

**Behavioural economics has shown that humans do not always act rationally.** Even when presented with all of the information, they sometimes make choices which do not maximise utility. However, given the right choices and tools, individuals can be encouraged to change their behaviour or actions[27]. For example, by making carbon intensity data available at the point of sale, E-Mission was able to influence food ordered by restaurant customers, resulting in lower carbon intensity of food choices[28].

Relying on consumers to process carbon information at each decision point is asking a lot – even more so when it is not a single decision but an ongoing optimisation process. Activities such as heating a house, charging an EV or eating a low-carbon diet all require a series of decisions and actions to minimise GHG emissions. **Digital technologies can help.**



What we eat accounts for 17% of an average household's carbon footprint.

# 5.3 Digital automation

Digital technologies have enabled the Internet of Things (IoT) to flourish. All manner of devices are now connected to the internet and can respond to external signals and make decisions. Consumers can set their preferences and let the digital technology handle the implementation.

**A range of energy-hungry products can now be controlled directly or via smart plugs.** Smart EV chargers[29] are of particular interest as they have the ability to control a significant electrical load which can be time-shifted without significantly inconveniencing customers. When combined with an automation service (such as IFTTT) and a time-of-use tariff[30], consumers can set their preferences to reduce their costs and carbon intensity.

**The advent of energy services which enable consumers to choose their outcomes and then let a third party (or digital system) implement their choices can help to provide a better customer experience and reduce GHG emissions.** The Energy Systems Catapult

Living Lab[31] has trialled 'Heat as a Service', which enables consumers to set their heating preferences and then let the system deal with the delivery. As long as the consumer is happy with the outcomes, the service provider could be free to use a variety of techniques to take actions which could improve energy efficiency or use low-carbon heating options.

The same techniques can also be applied to diet. Meal kit providers can enable consumers to make informed choices about their diet, which can be implemented for them week after week – providing more low-carbon options and expanding their culinary horizons.

**The use of digital technology could enable consumers to make automated choices about their GHG emissions across much of their lives, reducing the need for long-term behaviour change. If it is easier, it is more likely to be adopted.**
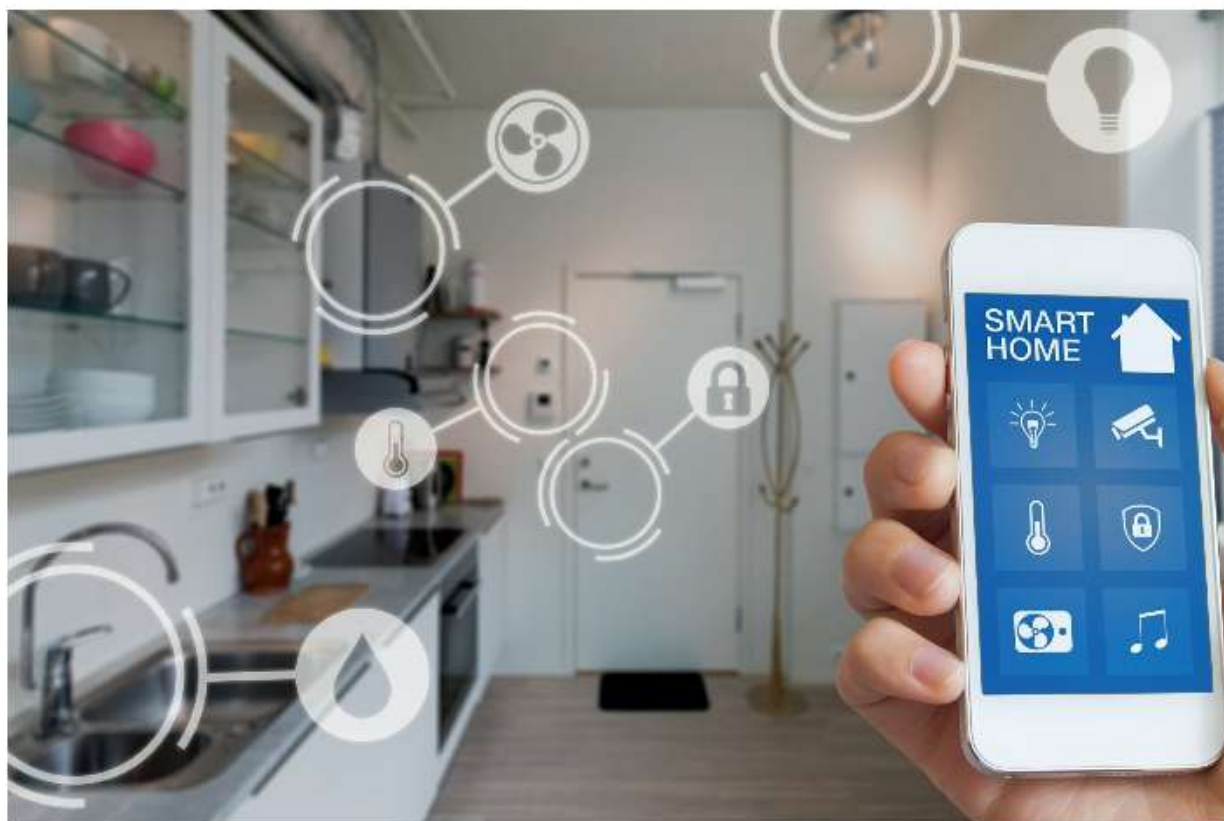
# 6. POLICIES FOR SUSTAINABLE CHANGE

**It is much easier to initiate good behaviours without policy intervention where there are no 'bad' habits to be broken.** So, there is a strong argument for establishing 'good' habits from an early age through climate-change education and raising children to adopt sustainable travel, consumption and wider civic practices. Many of the principles of behaviour change have been employed to change travel behaviour to a new primary school in South Wales. This has led to a sustained use of active travel modes (walking, cycling, etc.) by around 95% of pupils, staff and parents.

### Developing an Active Travel School – The Ysgol Hamadryad Story



I am extremely grateful to Dr Dafydd Trystan, Chair of Governors at Ysgol Hamadryad, for authoring this inspiring account of how a scholl can play its part in tackling some of our most challenging problems. The motorised school run is a contributor to climate change, childhood obesity, traffic congestion and poor air quality, to name but four; Ysgol Hamadryad's radical approach will have positive impacts on all of these. I am delighted to be able to publish the school's story as an aid to others who want to embark on this journey. Every school is different and what is possible in one may be more difficult in another, but I am sure this account will be useful to all schools who see the journey to and from school as a key factor in their commitment to sustainable development.

Huw Irranca-Davies AM
Assembly Member for Ogmore
Chair of the Cross Party Group on the Active Travel Act

In 2016, the governors at Ysgol Hamadryad decided that the new-build 21st Century School would be designated an 'Active Travel School.' Governors and parents were supported by the Cross-Party Active Travel Group at the Welsh Parliament and the school opened in 2019.

From initial concept through to the opening of the school, the school governors, teachers, parents and local councillors maintained an open dialogue. Barriers such as route planning, altering speed limits and designating new pedestrian and cycle routes were overcome through open dialogue and a motivated cross-functional team. In the early days of planning, the vision of an active travel school was seen by some as an unrealistic goal. But, using a consultative and inclusive approach, the active travel journey to school has become, for most children, their daily routine. The school did not provide parking outside the school and those parents who did park there were likely to receive a parking enforcement charge.

In the case of climate change, shifts in specific behaviours are important but so is broad public engagement and a perception of fairness. Barriers to desired behaviours also need to be reduced – to make preferred, low-carbon alternatives easier to choose.

The order in which measures are brought in is also important. Reducing barriers to new choices may be especially important as a first step, in preference to penalties for high-carbon behaviours. **Care needs to be taken when using penalties as there is always a risk of a backlash in the absence of alternatives which are zero/ low cost and easily accessible.**

www.huwirranca-davies.org.uk/wp-content/uploads/2019/11/Ysgol-Hamadryads-Active-Travel-Journey-Eng.pdf

# 6.1 Tax and public dividend

**Another promising way to combine penalties and rewards is a carbon tax that increases over time and then is paid back to the public as a cash dividend** (as Canada does now). This incentivises consumers to shift away from carbon-intensive goods and services through higher prices but also provides protection from these price rises for the poorest members of society.

# 6.2 Co-benefits

Behaviour change can be bolstered by leveraging the co-benefits of cutting carbon – particularly for health and the economy, including job creation[32]. The CCC estimates that if co-benefits of carbon emissions reductions were monetised across the UK as a whole they "would partially or possibly even fully offset the resource costs we have estimated[36]" (i.e. up to 1-2% of GDP in 2050). Co-benefits accrue *and can be enjoyed much more rapidly* than the climate change mitigating effects of reducing emissions. Therefore, co-benefits have the potential to drive and support the policymaking process[33] as well as behaviour change and public engagement. It will be vital to maximise these co-benefits, make them visible, and clearly communicate both their potential and accrual as progress is made.

# 6.3 Complex adaptive systems and social tipping points

The potential for co-benefits to drive increasing commitment and action in both behaviour change and policy change is one example of the potential for positive feedback loops – see points 3 and 4 in **Figure 8**, below.

Carmichael, R. (2020). 'Behaviour Change, Public Engagement and Net Zero: Building Momentum in Societal and System Change', Beesley Lecture 2020, 12th November 2020, online.
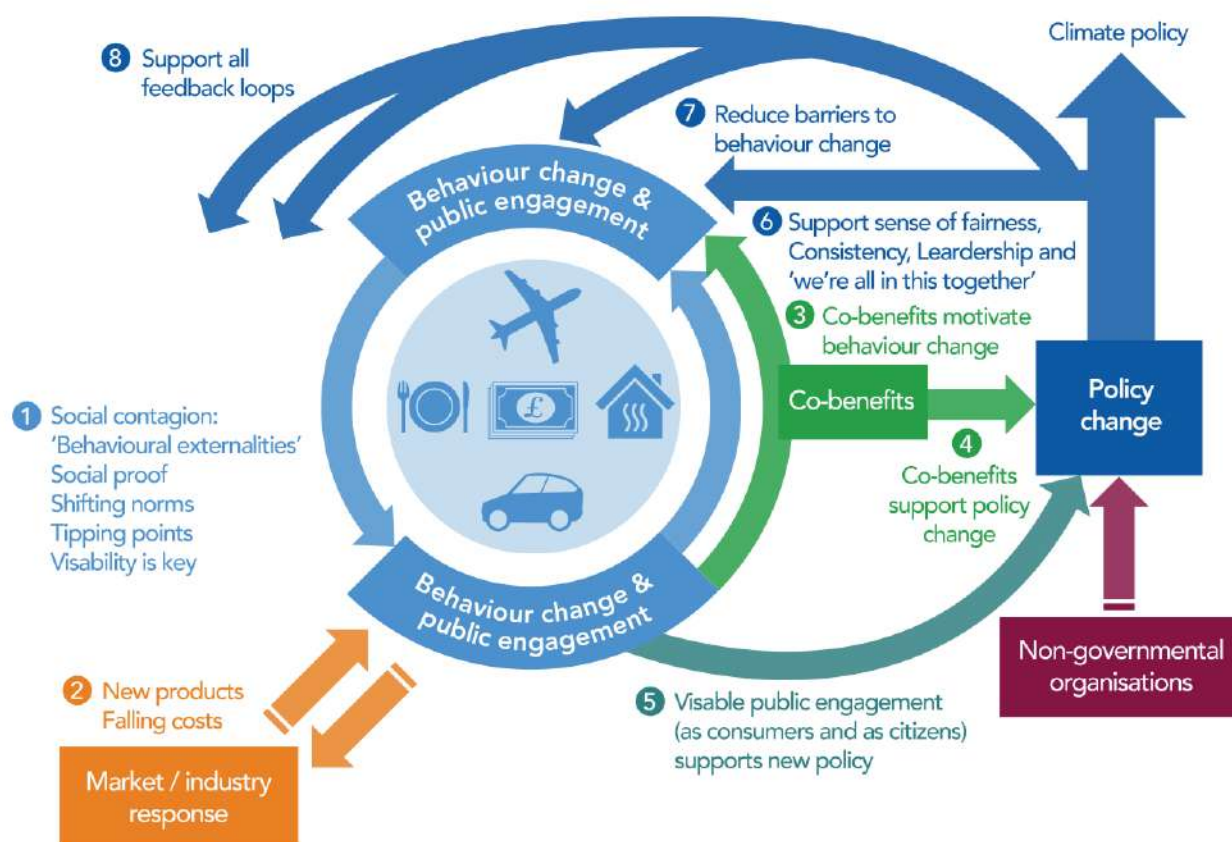


Figure 8    A framework for interventions to build momentum for Net Zero (Carmichael)

**There is a relatively short timeframe for reaching Net-Zero if global warming is to be limited to 1.5°C and it is crucial to accelerate the pace of change.** Increasing attention is being given to the concept of complex adaptive systems – in which components learn in response to change[34]. Within complex adaptive systems there is potential for 'tipping dynamics': self-reinforcing, positive-feedback mechanisms that can produce rapid, disruptive system changes. These represent an important opportunity for Net-Zero to cultivate "contagious processes of rapidly spreading technologies, behaviours, social norms, and structural re-organization"[35]. **Figure 8**, above, is a framework suggesting how policy and other interventions could support positive feedback effects to build momentum in societal and system change.

# 7. CONCLUSION

The current social environment is not conducive to the behaviour change needed for Net-Zero. There is evidence of 'social contagion' in a range of energy-related behaviours – including SUV sales, excessive calorie intake, solar-PV adoption, and electricity conservation[37]. More supportive social environments are needed to reduce negative *'behavioural externalities'* [38] that influence others to act in negative ways. Visible positive behaviour can trigger other people to make low-carbon choices[36].

There is great potential for better use of data and digital tools for reducing barriers and accelerating system change. The adoption of smart tariffs and other smart technologies through smarter digital comparison tools; leveraging data on savings and satisfaction from early adopters of low-carbon heating solutions; and supporting shifts to more sustainable and healthy diets through better collection of food-carbon data and personalised feedback on shopping habits.[37]

# 8. REFERENCES

1. Committee for Climate Change 2019. Reducing UK emissions: 2019

2. https://www.moneysavingexpert.com/news/2020/10/green-homes-grant-poll/

3. www.gov.uk/government/collections/provisional-uk-greenhouse-gas-emissions-national-statistics

4. Kurz et al., 2015 https://onlinelibrary.wiley.com/doi/pdf/10.1002/wcc.327

5. Verplanken et al., 1997 https://onlinelibrary.wiley.com/doi/abs/10.1002/(SICI)1099-0992(199709/10)27:5%3C539::AID-EJSP831%3E3.0.CO;2-A

6. Verplanken et al., 2008 https://onlinelibrary.wiley.com/doi/abs/10.1002/ejsp.587

7. Thompson et al., 2011 https://journals.sagepub.com/doi/abs/10.1177/1754073910380969

8. House of Lords https://publications.parliament.uk/pa/ld201012/ldselect/ldsctech/179/179.pdf, 2011; Capstick et al., 2014 https://link.springer.com/article/10.1007/s10584-013-1003-1

9. Verplanken et al., 2019; https://link.springer.com/article/10.1007/s10640-020-00446-9

   Birkmann et al., 2010, https://link.springer.com/article/10.1007/s11625-010-0111-3

10. Marsden et al., 2020, http://eprints.whiterose.ac.uk/160151/

11. Verplanken et al., 2019 https://link.springer.com/article/10.1007/s10640-020-00446-9

12. Thøgersen, 2012; https://onlinelibrary.wiley.com/doi/abs/10.1002/mar.20514

13. Bamberg, 2006 https://journals.sagepub.com/doi/abs/10.1177/0013916505285091

14. Verplanken & Roy, 2016; https://www.sciencedirect.com/science/article/abs/pii/S1369847818305874

15. Nicolson et al., 2017 https://link.springer.com/chapter/10.1007/978-3-319-97529-0_11

16. Whitmarsh et al., 2020 https://link.springer.com/article/10.1007/s10640-020-00446-9

17. Whitmarsh, 2009 https://www.sciencedirect.com/science/article/abs/pii/S0272494408000431

18. Lally et al., 2010, https://onlinelibrary.wiley.com/doi/abs/10.1002/ejsp.674

19. Carden & Wood, 2018, https://www.sciencedirect.com/science/article/pii/S2352154617301602

20. https://www.climateassembly.uk/

21. https://ora.ox.ac.uk/objects/uuid:b0b53649-5e93-4415-bf07-6b0b1227172f

22. https://voltagreentech.com/

23. https://www.opengroup.org/openfootprint-forum

24. https://www.climatetrace.org/

25. https://www.sciencedirect.com/science/article/pii/S0301421518303343

26. https://www.amjmed.com/article/S0002-9343(19)30553-4/pdf

27. https://link.springer.com/article/10.1007/s10602-008-9056-2

28. http://emission.org.uk/for-hospitality/

29. https://www.ohme-ev.com/

30. https://octopus.energy/blog/ifttt/

31. https://es.catapult.org.uk/service-platforms/living-lab/

32. Garrett-Peltier 2017; Hepburn et al. 2020; Jennings, Fecht, and De Matteis 2020

33. p.30, Committee on Climate Change (CCC). 2019. Net Zero: The UK's Contribution to Stopping Global Warming.

34. UNECE. 2016. "The Co-Benefits of Climate Change Mitigation, Sustainable Development Brief, N°2." (January).

35. CECAN. 2020. Magenta Book: Supplementary Guide: Handling Complexity in Policy Evaluation.

36. Otto IM, Donges JF, Cremades R, Bhowmik A, Hewitt RJ, Lucht W, et al. (2020) Social tipping dynamics for stabilizing Earth's climate by 2050. Proc Natl Acad Sci USA. https://doi.org/10.1073/pnas.1900577117.

37. Carmichael, R., Gross, R., and Rhodes, A. (2018) Unlocking the potential of residential electricity consumer engagement with demand response, Energy Futures Lab Briefing Paper, Imperial College London. https://www.imperial.ac.uk/energy-futures-lab/policy/briefing-papers/paper-3/

    Carmichael, R., Rhodes, A., Hanna,R., and Gross, R. (2020) Smart and flexible electric heat, an Energy Futures Lab Briefing Paper, Imperial College London. https://spiral.imperial.ac.uk:8443/handle/10044/1/82290

    Carmichael, R. 2019. Behaviour Change, Public Engagement and Net Zero, a Report for the Committee on Climate Change. https://www.theccc.org.uk/publication/behaviour-change-public-engagement-and-net-zero-imperial-college-london/

    Carmichael, R., Hanna, R., Rhodes, A. Gross, R., and Green, T. (2021) Renewable and Sustainable Energy Reviews, 139C; 110701. The Demand Response technology cluster: accelerating residential consumer engagement with smart tariffs, electric vehicles and smart meters via digital comparison tools. https://doi.org/10.1016/j.rser.2020.110701

OPPORTUNITY Education Availability
Pressure PERFORMANCE Fear Wealth
CAPABILITY Duty Value Social Behaviour
Knowledge Responsibility LIFESTYLE
Happiness SATISFACTION FEAR Wealth Financial SOCIAL
Opportunity Motivation Competitiveness
AVAILABILITY Lifestyle Financial Change HABIT Fear
CHANGE Anxiety Attitude
Evidence Capability
Pride Satisfaction WEALTH EDUCATION
Information
MOTIVATION Lifestyle Pride
Status Availability
Habit Responsibility Duty SOCIETY
VALUE Pressure Competitiveness
STATUS ACCESSIBILITY Value
Attitude Pride Opportunity
Duty INFORMATION FEAR FINANCIAL
Education Habit Social Behaviour
Wealth RESPONSIBILITY
Society PRESSURE Status Society
FINANCIAL Capability HAPPINESS Change
ANXIETY EVIDENCE Accessibility Status
Behaviour DUTY Evidence Anxiety
Information Satisfaction KNOWLEDGE
Education PRIDE ATTITUDE Happiness
BEHAVIOUR Knowledge SOCIAL
Motivation Performance Social EVIDENCE
Financial ATTITUDE Behaviour Habit
Knowledge Wealth
VALUE Society COMPETITIVENESS Duty CHANGE
Capability Pride Lifestyle Education