No-one left behind – Consumer empowerment, protection and universal service in the low carbon transition

Abstract

The context is the low carbon transition in which we will live, work and travel differently with heat and transport largely electrified. We consider the importance of electricity product choice enablement and architecture and the resolution of "bad choices" at both individual and collective levels.

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Introduction

Today I am going to talk about the electricity market window on the Low Carbon Transition, how the markets evolve, and some design issues that we need to consider now, so that the market works for *everyone*. The thrust of my argument is the enablement of consumer choice.

The fourth and fifth Climate Change Act carbon budgets have challenges in implementation of current policies, and some remaining policy gaps. The COP21 Paris Agreement commitments are a further challenge and we must also now consider targets beyond "80% CO2 reduction by 2050[1]" to limit global temperature elevation to 1.5℃[2].

This will require radical change, not just in the procurement of "kit" such as microgeneration, efficiency measures and smart automation, but in the "rhythm of life" way we live, work and travel in the next generation, and in addition an updated and bolder approach to personal, civic and corporate responsibility.

My focus today is electricity. To illustrate the key points I will use a scenario[3] of complete electrification of heat and transport, highly specified in terms of physical infrastructure, market arrangements, big data, and changes to the rhythm of life in the gig economy.

The challenges seem to be not technological, but political, cultural and regulatory.

There are two issues specific to electricity;

[1] Relative to 1990
[2] Relative to pre-industrial
[3] See the BEIS 2050 calculator https://es.catapult.org.uk/projects/2050-calculator/ for high level scenario construction

i) Electricity is an essential service - with totemic significance of absolute resilience and continuity of perfect power flow on the national grid
ii) Distributional issues - the digitised empowered prosumer[4], who both has the democratic right to participate in this emerging rich commercial landscape, and whose participation is absolutely essential to achieve the transition, has an engagement level and likely possession/utilisation of "kit" and automation that simply looks nothing like the passive consumer for whom the current market caters. There is risk of the disadvantaged getting left behind and even of cross subsidising the more enabled prosumers, violating the difference principle[5] in which all developments must benefit the least advantaged.

There seems then to be three questions to consider now;

i) No-one left behind by innovation - how can we ensure that no-one is left behind, for example because they are not sought by of have limited access to the innovative sector.
ii) Universal Service –It is becoming unclear what should be provided, by whom, at what price and how will it be paid for.
iii) Backstop provision – In a socially conscious nation, what does the provision look like for the basics of life, and what are the basics, e.g. transport?

This paper addresses from the standpoints of;
i) Market development and arrangements
ii) Social justice
iii) Consumer choice
iv) Universal Service and backstop provisions

Market Development and Arrangements

I would like now to convey a picture of how rich the choice landscape is about to become if we are bold enough to embrace it.

The electricity market is often described in terms of D's;

- Decentralised – power production is very widely dispersed including at consumer sites "behind the meter" at the network boundary. Local markets emerge, with the Transmission System Operator more residual than central
- Democratised - consumers have a greater choice in having (and paying for), and not having (and saving the cost of), certain services, for example can choose lower levels of continuity of supply
- Devolved – decisions affecting localities taken locally
- Digitised / Data driven – Both energy storage and consumption highly automated using live and near term projections of commercial signals and consumption needs
- Diffused – Knowledge, such as demand response, is widely diffused into the knowledge economy, to prosumers or to automation devices via heuristic analysis
- Decisive – Government continues to drives growth and resolve inequality through macroeconomic levers but in energy policy only makes the key big energy *infrastructure* decisions such as long term use of piped gases, as well as linking to major cross vector (e.g. road, rail, urban) infrastructure. The rest is left to the market and the regulator.

[4] The term generally used for consumers who also produce or store power
[5] After Rawls (1971), who goes further in that all developments should most benefit the least advantaged

Below is the prevailing “Central Station” model in which all power is pushed into the transmission grid and pulled out from the distribution network. We had highly flexible generation and inflexible variable demand.

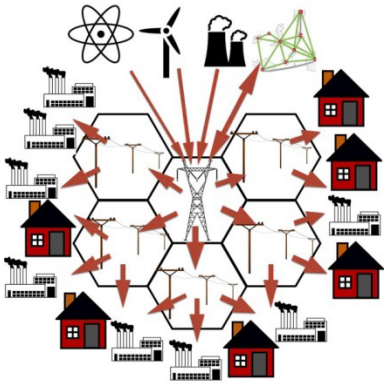

Figure 1 The “Central Station” electricity model

Whilst there have been some developments[6] over the last 20 years, the current market design is still largely “predict and provide”, in which it is determined centrally what consumers might and do “need”. The services are procured centrally and consumers[7] are required to pay for them. This conformed to the prevailing Public Interest Theory of Regulation[8], which broadly assumes that regulatory intervention is more efficient than market mechanisms. With diffused knowledge, we need to find a new way to embody public interest in the workings of the new decentralised markets.

We are moving to inflexible variable generation to flexible demand. The way that we live, work and travel will change and it will be responsive to ambient conditions in a way to which we have become unused over the last 60 years.

Figure 2 Power flow in the decentralised power model

The system is balanced much more by local actions with the Distribution System Operator, calling on actions by prosumers at the “grid edge” (at and beyond the ends of the network), as shown below.

[6] For example, the balancing mechanism that incentivises forecast accuracy and demand response, and ancillary service markets accessible to industrial consumers

[7] There is precedent abroad, e.g. Australia, for “grid defection”, in which consumers self supply and hence avoid the mandated charges

[8] Posner (1974)

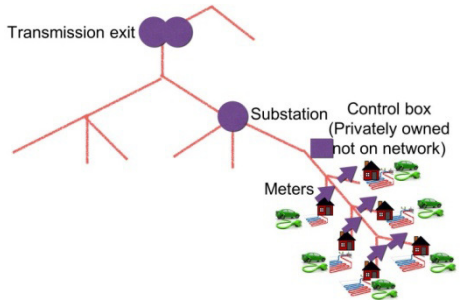

Figure 3 Automation at the Grid Edge

In technical terms, the new system may be characterised as below;

- GSP markets – Transmission power flow and infrastructure build is driven by nodal markets at the Grid Supply Points to the distribution systems. The Transmission System Operator (TSO) role is light touch and TSO only "trades" at GSPs.
- DSO – Distribution System Operators assume the previous role of TSO. Ancillary services with the TSO are contracted at the GSPs.
- Grid Edge – Lightly regulated markets open "behind the meter", for example peer-to-peer trading between Electric Vehicle charging points, which avoid local network overload
- Market access – Wholesale markets widely accessible, local markets open at the system boundary meter points and possibly at intermediate system points
- Widespread participation in ancillary services – reserve, interruption contracts, delayed return to service contracts[9], technical services such as voltage and reactive power and frequency response
- Big SCADA – The DSO "sees" the entire distribution system through the lens of the meters at the system boundary. All elements of DSO, including ancillary services are driven by commercial signals provided at meter points.
- Signal conflict resolution – where a market actor receives incompatible opportunities (e.g. demand more to take advantage of high wind but less to de-constrain the local network), the strongest signal prevails and other responses optimise the system

The figure below shows an idealised radial network, with no mesh connections at any layer. The circles are system nodes and the lines are electrical connecting wires. Looking at this from the bottom up, we can see that pro-sumption has local ("shallow") effects and "deep" effects all the way up to the system centre.

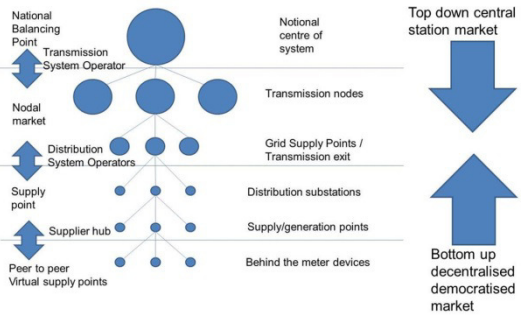

Figure 4 The linkages between market layers in the democratised electricity market

From the consumer perspective, there are four main effects of the new developments;

i) Energy supply charging will become increasingly cost reflective with the effect of cost to consumers becoming increasingly volatile and variable by location

[9] i.e. agreeing to delay return to service after system failure so that the system can get going without excessive load, in particular from latent thermal and electric demand (fridges, heating, batteries)

ii) Consumer accessible markets at the system boundary meter points, initially via the supplier hub, will be increasingly complex
iii) Lightly regulated peer to peer markets will grow in an indeterminate fashion but since they affect the system they will somehow connect to the main markets
iv) The expectations of universal service and backstop provision are becoming increasingly unclear

The current market arrangements are Supplier Hub, in which only the supplier contracts with the consumer, and the supplier contracts with wholesale counterparts and the transmission and distribution networks. The development challenges are more cultural than technical.

Social justice

The worth of our society is in large part measured by the treatment and welfare of our least advantaged.

One way of looking at this is shown below. Here we see how utility, welfare, (outcome) preference, (actual) choice, welfarism, paternalism and the segmentation of society relate to each other.

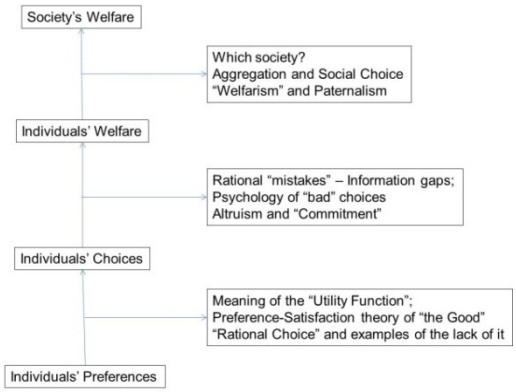

Figure 5 Welfare, choice and the best societal approach (from Beckerman 2011)

The key extremes of social justice archetypes, that consider inequality and fairness, that are available to us, appear to be;

i) "First Best Market" – Drive market efficiency and then trust the market to deliver maximum surplus, then resolve inequalities via the tax and welfare system[10]
ii) "Predict and provide" - Maximisation of a specified welfare objective by policy intervention, addressing distributional issues largely or partially within the energy system

The First Best approach relies on the first theorem of welfare economics to achieve the most efficient societal outcome using the market economy and the second theorem of welfare economics to redistribute wealth without losing efficiency, using the tax and welfare system.

This relies on the market economy working better, i.e. being complete, having no failures, and all choices being "good".

The making of "good choices" is closely related to having the resources for choice, whether they be cognitive/educational/cultural, access (e.g. financial, digital), financial resources (to

[10] This broadly corresponds to a Welfarist approach, with first best welfare measured using the money metric. The redistribution of wealth allows welfare maximisation under different measures (utility = log of wealth, sum ranking, maximin, etc.)

invest for long term gain), resource adequacy so that excessive abstinence is not required to make a choice, residual willpower resources in circumstances that drain the will, etc.. The resources for making good choices are broadly related to having high income and demographics that are associated with higher income.

We can view the choices in terms of bounded rationality. Some rationally do not spend the incremental time and effort to make incremental improvements to choices, but others do not have the choice resources, and act rationally with a heavily constrained resource.

Consider Rawls' eighth law of peoples[11]; "Peoples have a duty to assist other peoples living under unfavourable conditions that prevent their having a just or decent political and social regime". This goes beyond a prioritarianism approach to Universal Service and Backstop Provision – it is a right of *participation*. Indeed, the Committee on Fuel Poverty states[12]; "The energy market will function for households in fuel poverty".

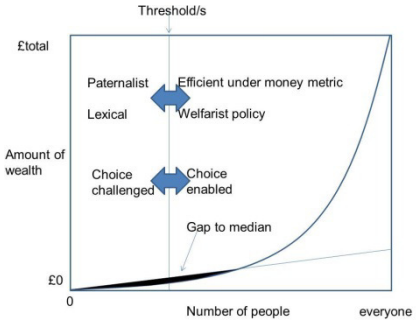

Figure 6 An approach to the energy market. Drive innovative market efficiency whilst taking a paternalist approach to specified cohorts of consumers. Lexical requires high central knowledge about specific needs and challenges

Good individual choices have externalities to other consumers that can be both good and bad. If an individual good choice of tariff does not reduce total system cost, then their saving may be redistributed to others' costs, but if (as we expect) the demand management stimulated by the tariff does reduce system cost, then the benefit is shared, as shown below.

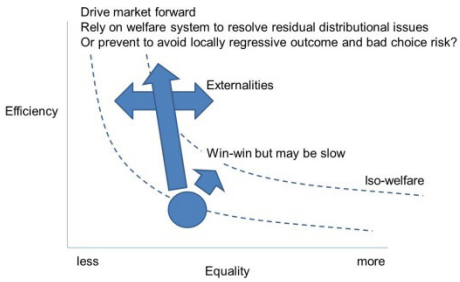

Figure 7 The policy choice about individual choices[13]

In UK regulation there is a strong culture of cost socialisation, so those who incur high system costs are cross subsidised by those who incur low costs. This conformed to the post war view of the "just price", "a price which is set with some regard for its effect on the

[11] Rawls (1999)
[12] CFP (2016)
[13] Welfare here is not the sum of individual welfares using the money metric. It may use wealth as a proxy for welfare and use a concave utility function or directly incorporate non-wealth metrics for welfare. See for example Weirich (2001)

distribution of wealth[14]". This is inefficient and does not conform to majority opinion amongst economists[15].

We have shrunk from cost reflective pricing, due to short term local distributional impacts that may be regressive, or otherwise regarded as "unfair". However, there are numerous cost differentiators (location, consumption pattern etc.). Each person has a basket of cost drivers and few will be the most expensive for all. Overall there is a strong efficiency gain on cost reflective charging for *all* factors, provided that the cost signal generates actions. The gain is further possible if we resolve distributional issues ex post.

Consumer Choice

To enable Low Carbon 2050 With No-one Left Behind requires three key elements of choice;

i) Procurement - for example in tariffs, kit and automation
ii) Rhythm of life - by allowing commercial signals (such as peak pricing) to influence how we live, work and travel.
iii) Civic responsibility - in embracing infrastructure change, voting, and procurement and rhythm of life changes.

"Many of our decisions are shaped by government policies that reflect policy makers' beliefs about our competence to make those choices[16]".

Below we show a depiction of the choice architecture. We start with an opportunity set created by all sorts of market actors. These may be, for example, tariffs and kit. Then we have the consumer decision process, which combines kit, tariffs and rhythm of life changes. Then we have the outcome. Unequal access to market may be doubly regressive for those left behind, through loss of choice, and cross subsidy.

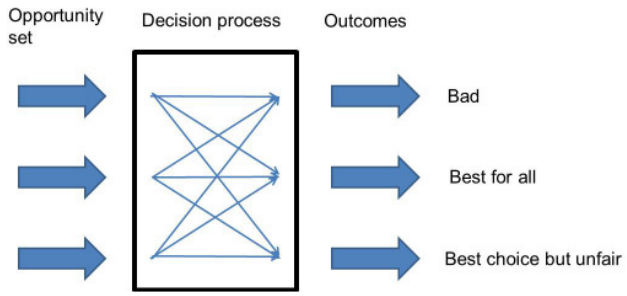

Figure 8 Simplification of the prosumer decision process

Now we can address our policy approach to choice.

Firstly, we can restrict the choice at the point of source, by limiting the provider (e.g. the number of tariffs) or the prosumer (e.g. no access to market) or be highly directive on the regulation of the presentation of choice. How libertarian or paternal to be is a broad social question. There is much experience to draw on here both inside energy (studies on tariff choices) and outside (e.g. the rules on gambling, suitability restrictions on financial products, credit controls, personal consumption of food and adult goods[17], etc.). The key in energy is to be consistent with the prevailing social model, which broadly speaking allows "bad

[14] Graaf (1957)
[15] E.g. Atkinson and Stiglitz (1976), Tirole (2017) and many in between, who advocate cost reflective pricing and corrective subsidy via welfare. Amongst numerous advocates of cost reflectivity is Crew (1968) and against inefficiency in universal service are Crandall and Waverman (2000),
[16] Fischoff and Eggers (2013)
[17] Consumed only by adults, e.g. alcohol and tobacco

choices" that have limited downside and limited externalities (e.g. drain on the health service deriving from the outcome of an activity).

Secondly, we can direct (or nudge) the choice, for example by providing public messages (e.g. regulator promotion of the benefits that smart meters can enable), agency support at an individual level (e.g. Citizens Advice, debt advisory services), and regulatory prescriptions on providers on monitoring the outcomes of choice. Experience in advice in personal finance is that education should begin in childhood and continue through life. Complete enablement in energy takes a generation[18]. We have a generation and must not squander the opportunity.

Thirdly, we "expect error[19]" even in the choice enabled cohort, then resolve "bad choices" ex post. Response to trial and error and associated learning drives change to choice architecture. This is done first by "sweep up" approach at an individual level. This attends to the specifics of individual circumstances with information garnered by customer contact and some analysis. For evolving thematic issues we can also take an "end of pipe" approach at a broader policy level. Note that financial recompense for "bad choices" made from properly conducted choice provision is problematic[20]. It is therefore essential that "bad choices" are spotted quickly and resolved. An example of sweep up is rudimentary checks for bills going up following selection of time of use tariff[21].

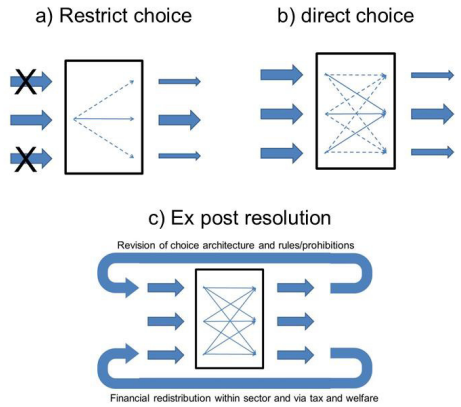

Figure 9 ex ante and ex post approaches to choice resolution

The key here in option (c) is that by the emancipation of choice, the overall benefit of the associated demand response creates the funding pool either for more intensive work with consumers to enable better choices, or to provide insulation and kit to give better choice access, or as a backstop simply to provide money to a cohort with limited choice resources.

The relationship between individual and bespoke sweep up of choices and the use of choice issues to inform wider solutions is shown below.

[18] MAS (2015)
[19] Thaler and Sunstein (2008)
[20] This is well known in environmental economics. The payment of compensation to those whose marginal damage is less than the compensation causes gravitation to the pollution zone and hence net welfare loss.
[21] This is done currently, for example by checking if bills would be lower if the customer changed from day/night tariff to flat rate tariff and then writing to the customers

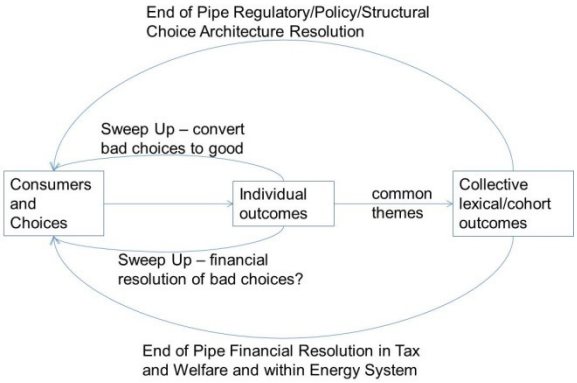

Figure 10 "Bad choice" resolution following bold emancipation of choice

To date we have many examples of choice provision in energy from which to learn valuable lessons, in which we may have let the perfect, be the enemy of the good as we fear the individual consequences of error. For example;

i) Door to door sales – Greater and greater ex ante controls and ex post sweep up by suppliers ultimately inadequate for public acceptance of this channel[22]
ii) The Green Deal "Pay as You Save[23]" model – Ex ante choice control architecture so unwieldy that the costs made the model non-viable
iii) Residential heat networks – Ex ante deterrent of private sector investment in capital projects due to regulatory concerns about consumer "lock-in" to contracts over the investment life of the equipment
iv) Smart grid – Ex ante deterrent of product offering due to consumer advocate concerns of benefit sharing before market forces have driven this up

Hence we need to find something in the golden middle. We need a configured approach based on the capabilities of citizens in choice making, feasible choice architectures and the capability of parliament to achieve cross party consensus.

If there is an association between the cohorts that make "bad choices" and identifiable cohorts who have less choice resources, then there is a case for compensating the *whole cohort*[24] and not diluting the incentive to make good choices. This does happen in practice, as there is an association between the recipients of benefit and those who engage less with their energy, for example by switching tariffs or suppliers.

We see this below. Light shading shows policy inefficiency in over-subsidy (bottom) and under-subsidy (top). The central area is the target subsidy. In black is inadequate incentive to make good choices.

[22] Mis-sale levels are hard to gauge from either ex ante or ex post savings, since tariffs change. From complaint analysis the level of mis-sales does appear to have got below 1% and possibly 0.5%.
[23] Consumers pay for energy efficiency measures via energy bills. The Golden Rule was that the energy saving led to net bill reduction
[24] This is broadly consistent with the Atkinson-Stiglitz (1976) approach in which high cost to serve customers experience the high costs but are given income benefits to offset this.

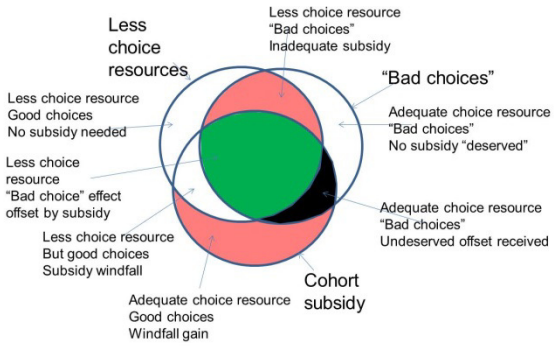

Figure 11 Approach to compensation for "bad choices".

In practice the picture is made more complex by the use of the energy sector for; I) more efficient redistribution of wealth when addressing specific poverty failures (e.g. fuel), ii) where delivering via the energy sector is more effective for engendering behavioural change, iii) where delivery by the sector is more efficient than the state.

Universal service and backstop provision

I now address the left hand side of figure 6, for those with less choice and other resources and more life challenges. In advocating that we forge ahead with the new market, it is not only important to endeavour to ensure that no-one is left behind, but to attend to those who are.

Firstly, let us apply definitions of Universal Service and Backstop Provision that are useful for current purposes.

For Universal Service we must;

i) Build the infrastructure for all to access
ii) On a reactive basis, offer terms of provision of basic service
iii) These terms should be "fair", with the meaning of "fair" clear in the specific context

We should also consider;

iv) Mandated reactive offering terms for products, services and innovation beyond the basic provision, where the provider already offers to some cohorts
v) These offers to be proactive, so that no-one is left behind

The first three requirements create the connection between provider and customer. This triggers a Backstop Provision, i.e. a provider, in common with family and society, incurs some responsibilities to look after their needs, where the product has a bearing on their lives. Historically, this was left solely as a legacy responsibility for post privatised companies, but as we shall see below; this alone is becoming no longer effective for consumers or sustainable in the competitive landscape[25].

I will address warmth for health first and transport second. Focussing on the left hand side of figure 6, our main question relates firstly to the treatment of subsidies. In warmth we have two stages; I) make insulation efficient so that heat stores well, ii) time of use tariffs to store heat at cheap times.

From a policy design the three choices are;

[25] The "rough justice" (term from Yarrow 1996) model of cross subsidised universal service is only sustainable if the cost is small and the cross subsidised are competed for (i.e. not left behind)

i) Where does the money come from, i.e. is it hypothecated within sector via bills or centrally via taxes[26]
ii) Who disburses it, does government deliver, or tender for delivery, or require the suppliers to deliver
iii) What are the customer choices

This is shown in the figure below.

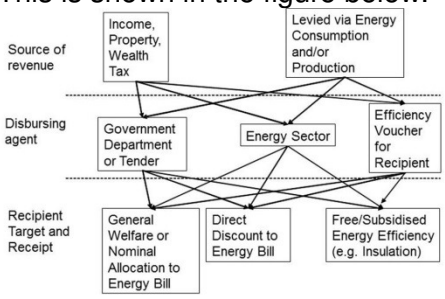

Figure 12 Choices on the paternal/libertarian axis and the efficiency/equality axis. Source Harris (2015)

The energy industry has the information resources for informed choice, for example the thermal characteristics of the building, the occupancy and needs, the energy costs, the costs of measures and finally the "golden rule" that for each installation the benefits should exceed the costs. Hence it is well placed to deliver insulation where appropriate (which is nearly always the case for the basic measures such as loft and cavity wall insulation).

Delivery of basic insulation (lofts and cavity wall) is almost always *financially* efficient; it is not always *welfare* efficient to deliver this universally for free, because;
i) The expectation of free delivery deters the "Able to Pay" from installing without financial support[27]
ii) It may be regressive, due to higher income people having larger properties

We then have three questions;
i) Who is the target population
ii) What is the percentage of subsidy intended to be spent on heat
iii) How directive to be on spend on heat (and efficiency of heat)

These three inter-relate. For example if we have a general target population and want to direct the spend to heat, then we may limit the general target population to bill payers. Further, we wish to target heat benefit to those households for whom the cost to heat adequately is a disproportionately high percentage of income. This is generally a combination of poor thermal properties of the building and low income - As an essential "Engel" good, the lower the income, the higher the percentage spent on fuel.

The *actual* spend on heat may be less than a normative/paternal view, based on "laundered[28]" preferences, for example the removal of adult goods, to get to "right choices". This is shown below, with a simplified utility tree, in which goods are divided into heat, other essentials and "non essentials", which may include adult goods. Assuming no saving, then the sum of normalised income elasticities of demand must equal unity (one).

[26] There is some realpolitik here, where a government may wish to avoid visible taxes, or otherwise avoid visibility of implied energy levies (the mechanism in the UK being the Levy Control Framework following the Comprehensive Spending Review). This is not addressed here.
[27] The most recent ECO and predecessors (EESOPs, EECs, CERTs, CESPs, ECO) never stipulated free delivery but expectation setting in practice made free delivery mandatory and indeed suppliers did have to offer incentives to accept free delivery
[28] Hausman (2012). Note that the Rowntree normative basket of goods has generally included adult goods and some "non essentials"

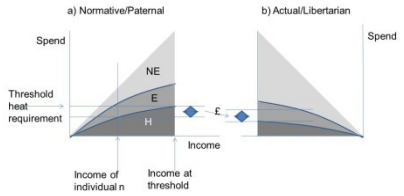

Figure 13 Income elasticity of demand for different costs[29]. H denotes heat. E denotes essential goods, NE denotes "non essential" goods. The diamond is the fuel poverty gap.

We can see from the diamond on the left in the figure, that for a given income, even if budget allocation is "best" there is a gap between actual and required fuel spend. The issue with providing money to solve this is;

i) Below a threshold income the problem is likely to be income not heat, and spend on something else other than heat may be better from a normative perspective
ii) If the fuel gap is paid in money, then it is perfectly rational for the consumer to spend on other than fuel. Hence the fuel poverty gap will remain, and will do so until *income* is sufficient.

Our main focus here is not where there is an income problem – as this is responsibility of the state – but where there is a "wrong choice" problem.

The simple choice architecture is shown below.

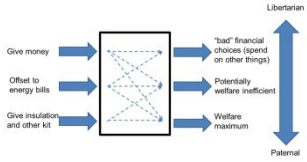

Figure 14 Choice architecture for the provision of heat

We actually have nearly the complete spectrum from paternal to libertarian already in place and can adjust the volumes of each up and down;

i) Energy Companies Obligation (ECO) – energy efficiency measures delivered by non exempt suppliers to consumers who are not necessarily customers. Funded within sector.
ii) Fuel Direct (FD) – a welfare benefit paid direct to suppliers to offset bills
iii) Warm Homes Discount (WHD) – paid by non exempt suppliers as a bill discount[30]. Funded within sector.
iv) Government Electricity Rebate (GER) – paid via suppliers to customers but not as a bill discount[31]
v) Winter Fuel Payment (WFP) – paid by government, labelled as energy related[32]
vi) General welfare – paid by government and used at recipient discretion to pay fuel bills, or not

There is an interesting seventh option, being broadly opposite to GER;

vii) Raise levy on energy and redistribute in general welfare. This is broadly in line with that proposed by the Green Fiscal Commission[33]; The idea is that energy efficiency rises and the regressive effect of a flat levy is overcome by distributive efficiency in welfare payments.

[29] Simplified, e.g. Ignoring Inferior and Luxury goods
[30] Mandated to non exempt suppliers. Of additional interest is the Fuel Bank™ charitable scheme operated by the Trussell Trust and supported in part by npower in which consumers visit and collect vouchers which can be applied as discounts to their Prepayment Meter account costs
[31] Suppliers were reimbursed via general taxation. GER was a one off, conducted over two years
[32] Cold Weather Payments, paid if the weather is particularly cold, is the same
[33] GFC (2009)

Sunstein (2014) notes that "in certain contexts, people are prone to error, and paternalistic interventions would make their lives go better", social welfare is the "master concept" and a "stronger response may be justified after careful consideration of benefits and costs".

Paternalism[34] here involves two steps;

i) a normative judgement on what is "good"
ii) action, for example by mandation, persuasion or prohibition.

The advent of prohibition is generally politically non viable without cross party consensus. For example disallowing building works without wider home insulation was proposed by government and then abandoned. Conditioning receipt of heat subsidy on accepting free insulation is very unlikely to be politically workable. Sunstein (2014) is clear that in Behaviourally Informed Regulation, nudge rather than coercion and prohibition should always be tried first. Indeed nudge has been very successful, even transformative.

The Winter Fuel Payment is a case in point. The WFP is a payment to the elderly, not restricted to billpayers, funded by general taxation, arriving before Christmas and not mandated[35] to spend on fuel (as, for example the Fuel Direct welfare payment is). The evidence[36] indicates that in the absence of specific labelling, on average only 3% of incremental pensioner income would go on fuel. This is rational with respect to the income elasticities of demand for different goods. In fact 41% of the WFP is actually spent on fuel. As the research shows, this dramatic difference to 3% results from the "nudge". So here we have a benefit managed entirely within tax and welfare, but the delivery mechanism and wording having a big impact on behaviour.

The target population for energy sector intervention is those who must spend a disproportionate percentage of income to stay warm. Indeed, over the years, of the two objectives of overall energy efficiency and resolution of fuel poverty, the focus of energy company obligations has moved towards the latter. We have two standard metrics for the target population, being; i) more than X% of income required spend on fuel to stay warm[37] and ii) the extra income needed to bring the household above the Low Income High Cost dual threshold[38].

Having attended to insulation, I would like now to look at electricity bills in the specific context of electrification of heat.

I made clear above that demand must be highly responsive to make best use of ambient energy resource such as sun and wind. This means time of use tariffs with strong variations. The cost to deliver flat rate Full Service Contracts with no demand response will become very high. What then does Universal Service mean. We can offer standard terms to all customers that are fair (i.e. cost reflective) but bills will rise for those who don't respond (as they incur high system costs). Universal service is now not enough to protect all citizens, because the third element – an affordable price – cannot be satisfied without subsidy for flat rate tariffs.

[34] See Hausman et al for a more detailed description
[35] Interestingly, when this is measured, government subsidies such as WFP are applied to the income line and not the cost line.
[36] Beatty et al (2011)
[37] Townsend (1979) used the Engel (1895) approach to define this (see Deaton and Muellbauer for exposition of this). Boardman (1991) used X%=10% for her seminal policy work on poor housing
[38] Hills (2012)

One backstop solution is backstop tariff, being a subsidised tariff. If this is at flat rate then it is essential to maintain the incentive to move to time of use tariff. The next stage from insulation may be home automation, for example focussing room heat to room occupancy and, *where health permits*, having a degree of thermal discretion according to prevailing prices.

Whether flat rate or limited time of use, some subsidy is still required and the money must come from somewhere. Tirole (2017) advocates the raising of revenue by sector levies, to fund the provision of universal service.

Now let us turn to transport.

Looking forward to the electrification of transport, where everyone who has a car has an electric car, addressing universal service and backstop provision is more complex than for heat. For example;

i) The connection between supplier and driver is less clear since charging can be away from home
ii) Transport is not an "Engel" essential good and hence income is a poor indicator of "transport-poor"
iii) Transport needs are highly individual and subject to change
iv) Personal transport is just one way of travelling and public transport substitutes are highly dependent on individual locations
v) The national infrastructure has complex cross vector relationships between road, rail, electricity and urban planning

In reality then, it may well be that there becomes a universal service requirement (to fit a charging device on reasonable terms on request) there is no backstop provision of energy. Without a backstop it is therefore essential that the market works for everyone. Somehow or other we must enable innovative service provision and choice making to everyone.

Conclusion

The way that we life, work and travel must and will change dramatically over the next generation. Electricity, and its associated cost, is likely to be the key medium by which we respond to dynamic ambient conditions, for example the weather.

It is very possible for the electricity market to evolve to meet the challenge and it is essential that this is done progressively so that no-one is left behind. This can be done by a bolder approach to consumer choice and market participation than we have had to date.

We must always have a backstop so that those who, despite our efforts, are left behind. The market and fiscal design for this needs careful consideration, in particular in relation to universal service and backstop provision of essentials.

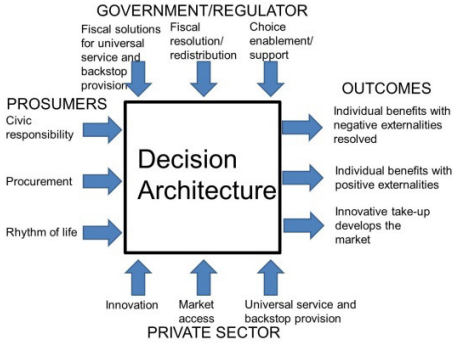

Figure 15 Roles and outcomes in the Low Carbon Transition

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Caveat

The views are those of the author and do not necessarily represent the views of npower or London Business School