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The evidence on engagement with demand response

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Overview

- Context/work in this area
- Categories of intervention and assessment metrics
- Evidence on participation, response and persistence
- Why consumers respond/don’t
- DR in models
- Conclusions

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Work in this area

- HubNet Position Paper no. 11
- **How much can we really expect from smart consumers?'**
- Systematic review of the evidence base on residential demand response, focussing on trials, pilots and programmes that include consumer engagement with demand response
- Aim was to assess how far the current visions of residential demand response are supported by the available evidence

- BEIS report
- **'REALISING THE POTENTIAL OF DEMAND-SIDE RESPONSE TO 2025:** A focus on Small Energy Users - Rapid Evidence Assessment report' https://www.gov.uk/guidance/funding-for-innovative-smart-energy-systems
- What is the role of policy in promoting DSR from smaller users, what has worked and why?
- What novel business models are being used to access DSR from smaller users, have they worked and why?
- What DSR products and services have been used internationally to secure demand response from smaller consumers?
- What are the key factors affecting consumer engagement in terms of: recruitment, level of response and persistence?
- Forthcoming – Energy Futures Lab Briefing Paper, two academic papers

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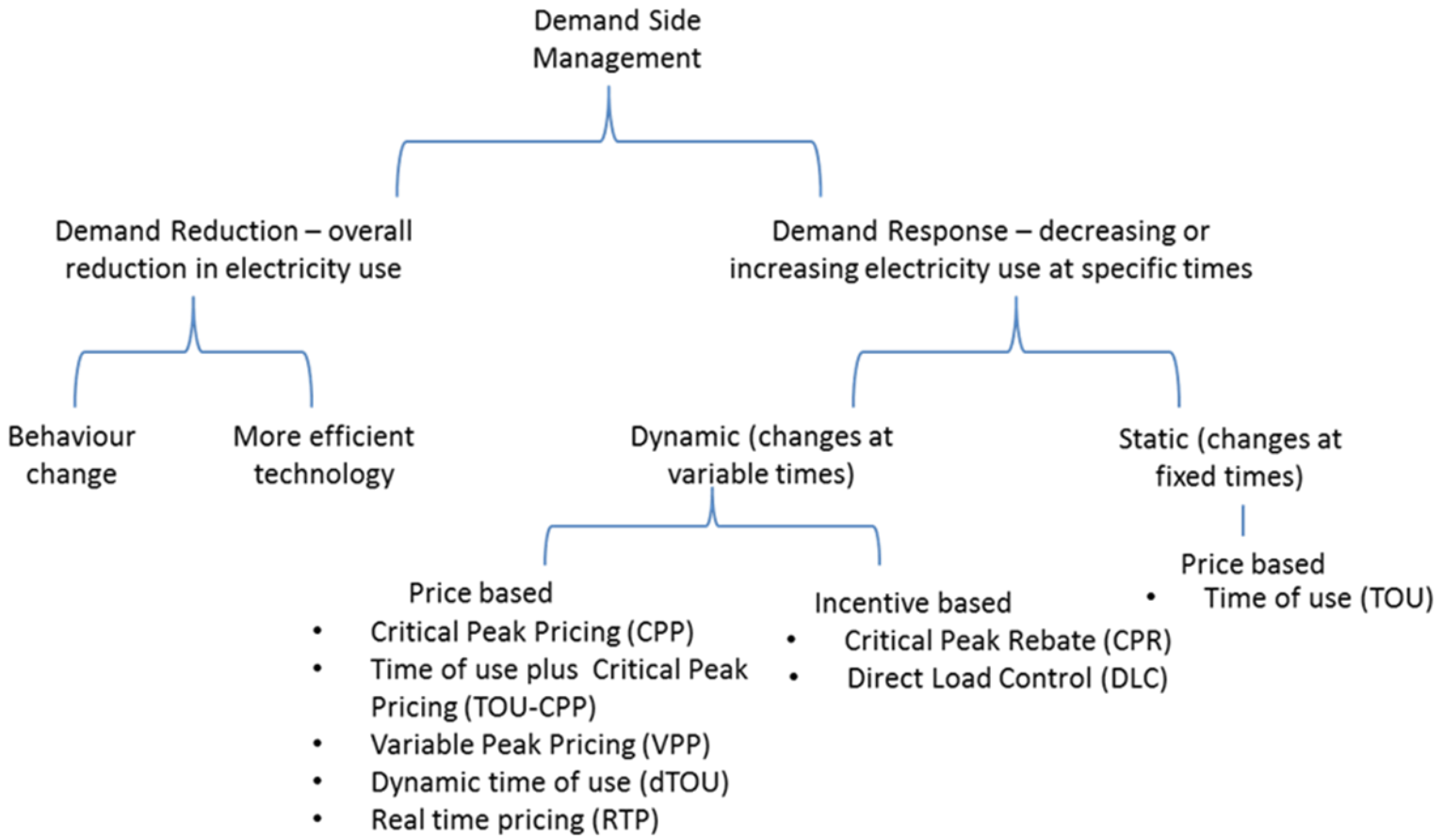
Categories of intervention

Following EPRI (2012) need to consider: –

Participation – engagement/recruitment of consumers

Response – action by consumers in response to programme

Persistence over time – do consumers stay engaged and continue to respond?



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More detail on intervention types

Price based schemes	Description
sTOU (static time-of-use)	Prices vary by time of day between fixed price levels and over fixed periods. These may vary by season.
CPP (critical peak pricing)	Prices increase by a known amount during specified system operating or market conditions. This applies during a narrowly defined period and is usually applied only during a limited number of days in the year.
TOU-CPP (time of use plus critical peak pricing)	Critical peak pricing overlaid onto time of use pricing. TOU-CPP therefore has two pricing components – daily time of use pricing, and occasional critical peak pricing applied during critical system events (Fig. 3 refers to these as TOU-CPP-D and TOU-CPP-CE respectively)
VPP (variable peak pricing)	Similar to time of use, but the peak period price varies daily based on system and/or market conditions rather than being fixed.
dTOU (dynamic time of use)	Prices vary between fixed price levels, but the timing of different prices is not fixed.
RTP (real time pricing)	Price can differ on a daily basis and change each hour of the day (or more frequently) based on system or market conditions.
Incentive based schemes	Description
CPR (critical peak rebate)	Similar to CPP, but customers are provided with an incentive for reducing usage during critical hours below a baseline level of consumption.
DLC (direct load control)	Customers are provided with an incentive for allowing an external party to directly change the electricity consumption of certain appliances. Customers can usually override control although they may lose some incentive. DLC may also be combined with time varying pricing.

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Evidence on participation

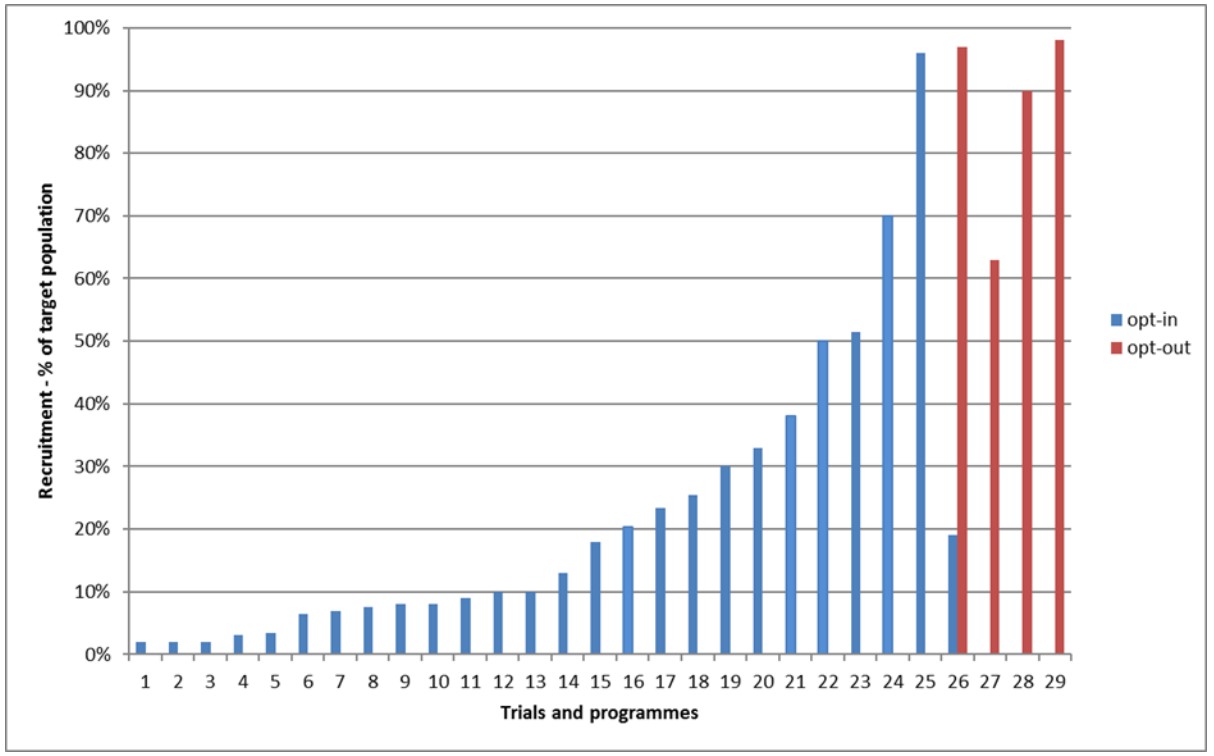
Recruitment ranges from near zero to nearly 100%

Half the trials and programmes reviewed got below 10% of target population to sign up

Opt-out recruitment gets high levels of recruitment (not surprisingly)

But evidence suggests % participation rates lower for opt-out

On balance participation similar across both – is opt-out easier and cheaper? More likely to create unhappy/disadvantaged customers?



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Response summary

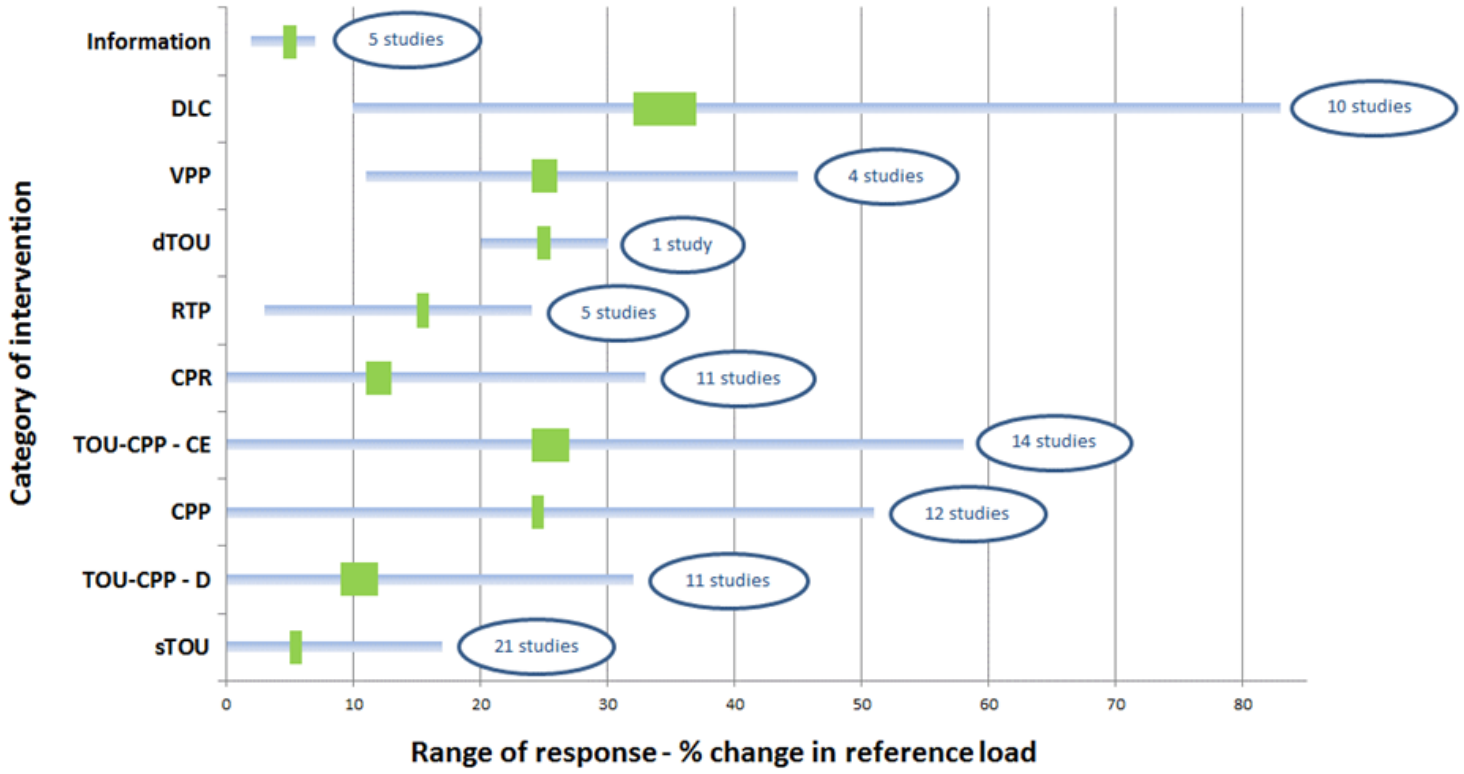
So how much load shifting do you get?

Answer is it depends – very wide range for all intervention types

But direct load control (with incentives/penalties) highest median – sample includes many traditional static/peak schemes

Information only is pretty useless

Much more evidence on static than dynamic pricing



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Not much evidence on persistence over time…

	enrolment			response		
	increase	decrease	stable	increase	decrease	stable
trials	1	1	4	1	3	5
programmes	6	1	1	1	3	6

Persistence of enrolment and response across two or more years

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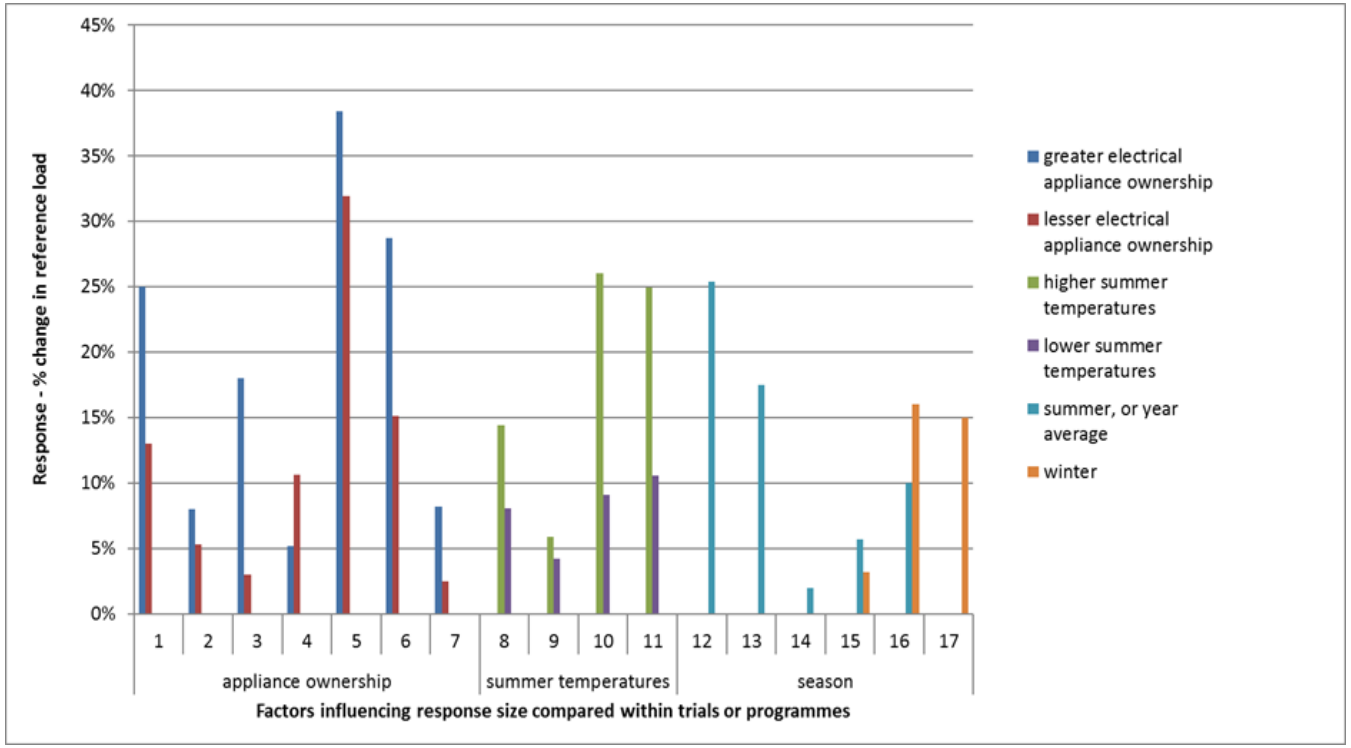
Factors affecting enrolment and response

Factors include:

Automation

- High impact

- Real time information
  - Low/zero impact
- Appliance ownership
  - Type/size of load key
- Climate
  - Inconclusive
- Price ratio
  - Inconclusive/limited importance



But evidence is complex and somewhat contradictory

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Enrolment, response, persistence by type of intervention

Product design features	Enrolment	Response	Persistence
Larger vs smaller price ratio	No evidence identified	Mixed results. Often co-varies with other DSR characteristics, complicating evaluation	No evidence identified
Rebates vs pricing	Similar for both pricing and rebates, though some evidence that enrolment in rebate schemes is lower risk	Smaller and more variable for rebates	Slightly higher for rebates
In-home display	No impact on measured enrolment rates in US CBS[3]	Mixed results	No evidence identified
Automation/direct load control	No evidence on measured recruitment rates, but automation suggested as a motivator for some users	Presence of automation and direct load control tends to increase response	No evidence identified
Opt out vs opt in recruitment	Much higher for opt-out	Lower average response for opt-out. Similar aggregate response, although evidence is mixed	Limited and mixed evidence. Some evidence that consumers made worse off through opt-out seek to leave DSR schemes

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Motivations/enables/barriers

	Enrolment	Response	Persistence
Motivation	Mainly financial benefits, with a secondary focus on environmental and social benefits	No evidence identified	No evidence identified
Familiarity with and knowledge of DSR	Reputation/awareness of DSR and supporting technologies may be a barrier or enabler	Lack of technical skills and understanding of DSR may decrease response	No evidence identified
Trust	Barriers may be associated with organiser motivations, privacy and autonomy	Trust may be undermined by poor technical performance, delays or unexpected outcomes. Could be reduced by proactive management and open communication about any problems, and provision of clear information about the range of outcomes consumers may expect of a DSR programme	
Technology requirements and technical issues	Absence of certain technologies or requirement to install new technologies can act as barriers to enrolment.	Technical problems, especially with communication, can limit response	Technical problems may reduce engagement and erode trust
Risk	Stated preferences suggest financial risk is a barrier, but little difference in recruitment rates for critical peak rebates and critical peak pricing in US CBS	Financial risk may increase response (evidence on higher price levels, price rather than rebate)	Financial risk may decrease persistence (Retention somewhat higher for critical peak rebates than critical peak pricing in US CBS)

	Enrolment	Response	Persistence
Perceived control	Concerns may be associated with direct load control, and be reduced by override and other control options	Concerns may increase or decrease following actual experiences of direct load control or smart automation, influenced by familiarity, level of feedback and control options provided to users	
Complexity and effort	Perceptions of and experienced ease or difficulty of response can change with DSR product/service - in particular automation may reduce perceived effort and enable response (though some automation can itself can be difficult to use), while more complex pricing may increase perceived effort and hinder manual response. Perceptions and experiences also seem to vary amongst users		
Interaction with user routines and activities	No evidence identified	Automated responses to heating/cooling may have minimal impact on routines. Manual response involving wet appliances appears to be limited. Demand shifting could be enabled if it fits well with existing routines, or does not affect routines. Some users make larger changes to routines and activities	

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Summary findings on consumer engagement

- The primary motivation for enrolment is financial, but environmental and other drivers are also significant.
- Trust, risk and complexity feature strongly in the evidence base on motivations for enrolment, response and persistence. The presence of trusted actors, absence of perceived risk of higher bills and minimal complexity all enable engagement.
- Beyond this the evidence presents a complicated and mixed picture, e.g. of who is trusted and how to minimise risk or complexity.
- The evidence base contains considerable attention to routines, with both daily and seasonal factors affecting response.
- There is a considerable amount of discussion of various end user types/segments and clear evidence that some households respond much more than others.
- The evidence is too complex and varied to reveal any simple overarching conclusions about which consumers are most responsive to DSR offerings and why.

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Assumptions made by modelling studies featuring residential demand response

Study	Assumed demand response type	Assumed participation (% of target population)	Assumed electrical loads participating in demand response
Aunedi et al. (2013)	Automation	100%, 75%, 50% and 25%	Refrigerators
Boait, Ardestani and Snape (2013)	Real time pricing	70%	Heat pumps and electric vehicles
Dallinger and Wietschel (2012)	Not specified	100%	Electric vehicles
Dupont et al. (2014)	Automation	100%	Washing machines, dishwashers, tumble dryers, electric vehicles.
Falsafi, Zakariazadeh and Jadid (2014)	Not specified	Not specified	Not specified
Finn, O'Connell and Fitzpatrick (2013)	Not specified	Not specified	Dishwashers
Fitzgerald, Foley and McKeogh (2012)	Automation	6% [A]	Electric water heating (immersion heaters).
Hamidi et al. (2008)	Static time-of-use PLUS dynamic pricing or automation for wind supply following	16% (static time of use), 15% (wind following).	Cold and wet appliances, water and space heating.
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Le, Jhi-Young and Ilic (2009)	Real time pricing	Not specified	Not specified
(Pourmousavi, Patrick and Nehrir(2014)	Direct load control PLUS static time-of-use pricing	100%[B]	Electric water heating
Pudjianto et al. (2013)	Not specified	Not specified	Heat pumps with thermal storage, and electric vehicles.
Roscoe and Ault (2010)	Automation PLUS real time pricing	100%	Various appliances
Stanojevic et al. (2013)	Automation	100% [C]	Dishwashers, washing machines, tumble driers.
Taneja, Lutz and Culler (2013)	Not specified	20%	Refrigeration (prototype using phase change materials to increase thermal storage)
Wang et al. (2012)	Automation	Not specified	Heat pumps
Westermann and John (2007)	Not specified	Not specified	Not specified

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Some observations

- Around a third of modelling studies reviewed assume high participation and response - 4 studies explicitly specify 100% of modelled load shifted
- Studies generally take care to establish the technical basis for load shifting (journey made by light vehicles, or modelling fridge duty cycles), but tend not to explicitly consider the extent of consumers engagement with the interventions modelled
- Eight include some form of automation, and three assume real time pricing or a similar dynamic price signal
- Majority focus on benefits from shifting a particular type of load - including appliances consumers currently have little experience of, such as electric vehicles
- Some studies explicitly consider response rates, few engage with participation or persistence

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Conclusions

- Good evidence that at least some residential consumers are willing to participate in at least certain forms of demand response
- BUT, any plans to increase residential demand response to provide greater flexibility in a decarbonising energy system should take account of likely consumer engagement and other issues based on the available evidence
- The best evidence is on the least ‘smart’ options, such as static peak pricing/load control, which are well established and proven - may offer many benefits sought in modelling studies but not dynamic load following/response
- However, more research and greater empirical evidence is needed to establish the potential role of more innovative and dynamic forms of demand response
- The evidence appears is complex and mixed, but the high levels of demand response modelled in some future energy system scenarios may be more than a little optimistic

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Thanks very much

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