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The History of Heat-as-a-Service for Promoting Domestic Demand-Side Flexibility: Lessons from the case of Budget Warmth

Abstract
Heat-as-a-Service (HaaS) involves the provision of agreed room temperatures at certain times for a fixed fee, instead of charging for energy use on a per-unit basis. This arrangement enables the operator to remotely manage the heating system to use electricity when it is cheaper, thereby maximising profits, and exploiting opportunities for 'flexibility' in response to information about the state of the wider power system. In this article I present the case of Budget Warmth, a HaaS tariff offered commercially in Great Britain in the 1980s. I suggest reasons for its failure (despite early enthusiasm), including tensions between occupant expectations and operators' commercial interests, and lack of incentives to provide flexibility within the system as whole. I then consider the extent to which these challenges exist for HaaS offerings today.

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INTRODUCTION

1 The United Kingdom (UK), in line with many other industrialised countries, is exploring ways to rapidly decarbonise its energy system. In the domestic sector, the largest source of energy demand and carbon emissions is heating[1], which is therefore a key target for decarbonization efforts. Multiple challenges exist in decarbonising heat, including reducing heating demand, increasing the adoption of low-carbon heating systems and, when they are powered by electricity, the management of large and potentially peaky loads which can cause network management problems.

2 One response to these challenges that is increasingly the focus of research is the provision of heat-as-a-service (HaaS). In essence, this involves a shift from selling units of energy to customers to selling a package which assures a certain level of heating for a fixed price, independent (as far as the customer is concerned) from energy use. Operators then endeavour to reduce the energy input required to provide the agreed level of warmth, and manage overall energy usage patterns in as cost-effective a way as possible. This approach makes it easier to spread the costs of expensive low-carbon heating systems over time, also giving customers and suppliers with the reassurance of a regular, and reliable fee.

3 HaaS has the potential to support decarbonisation in three key ways. First, it incentivises suppliers to minimise required heating energy input overall (and therefore carbon emissions associated with this energy). Second, it can support uptake of heating systems powered by lower-carbon energy sources (e.g. electricity rather than natural gas, in many countries). And third, it incentivises suppliers to use energy at times when it is cheapest – and for electricity, this often coincides with times of high (low marginal cost) renewable generation[2].

4 Because of the potential of this approach to contribute to decarbonisation, it is important not only to research new HaaS offerings, but also to consider those that have already been tried out to see if there are any lessons to be learned. To that end, in this paper I examine the case of a HaaS tariff called "Budget Warmth" which was first made available in Great Britain (GB, or the UK excluding Northern Ireland) in the 1980s. I describe how and why that tariff came about, how it worked, and consider why it did not lead to further widespread development and adoption of HaaS offerings. This work is based on archive material (including industry journals, reports, and newsletters, as well as government records) plus an oral history interview with a former economist at the Electricity Council. (For more details on the process for identifying these materials, please see Appendix A.)

5 In the last part of the paper, I compare the situation that pertained in the 1980s with the present, in order to identify points of continuity and difference. While there have been significant steps forward in areas such as data collection, control capabilities, and user-centred design, challenges still remain. These include limited market incentives for suppliers to stimulate demand-side flexibility, the requirement for (potentially long) contracts to cover the cost of installed technology, and issues around fairness. First, however, I provide some further background on the concept of HaaS and its connection to the concept of flexibility.

HEAT-AS-A-SERVICE: WHAT AND WHY?

6 Today, people in cool and temperate climates heat the spaces they live in for a variety of reasons, including creating a healthy and comfortable environment for themselves and others, to

1 *Digest of United Kingdom Energy Statistics 2019* (London: National Statistics, Department of Business, Energy and Industrial Strategy, 2019), **https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/840015/DUKES_2019_MASTER_COPY.pdf.**

2 Iain Staffell, "Measuring the Progress and Impacts of Decarbonising British Electricity", *Energy Policy*, 102, 2017, 463-475. DOI:10.1016/j.enpol.2016.12.037.

maintain the fabric of buildings, to dry clothes, and so on. The basic elements of space heating are:

- a space to heat (which may be better or worse at keeping the heat in)
- a heat source such as a boiler
- possibly a storage option like a hot water tank and/or distribution system such as a network of radiators
- possibly an additional control system such as a thermostat
- and an input of fuel such as gas.

7 According to a definition I have previously set out, the energy service 'space heating' is used to provide the 'end service' of a warm environment[3].

8 How is this warm environment usually paid for by users? Generally, the infrastructure – the space to be heated, the heat source and distribution system – is owned outright or rented by the occupants from a landlord. The fuel or vector, such as electricity or gas, is bought from an energy supplier through a combination of a standing charge to cover fixed costs (such as network charges) and a price per unit used (kilowatt hour). In this case, occupants do not pay for a 'warm environment' – rather they pay for the combination of infrastructure and energy input to provide the energy service of space heating, which creates the warm environment.

9 Heat-as-a-service models charge for warm environments more directly. For example, occupants might pay to have a certain number of hours at a certain temperature, independent of the amount of energy input (as was the case in recent trials by the Energy Systems Catapult in the UK[4]; for more detail see below, this section). Occupants no longer pay for heating as such; they pay for a warm environment. Indeed warmth-as-a-service – which conveys the meaning of heat as an outcome rather than a process or output – could be an alternative description (see also[5]). A HaaS provider may own, operate or influence any part – or all – of the infrastructure. For example, such an organisation could replace and maintain the heating system, or improve insulation in a home. The service provider then buys in sufficient energy input to meet their commitment to delivering a certain level of warmth.

10 Such models have several interesting implications. If providers are tasked with creating a warm environment for a fixed fee, part of their profit opportunity comes from minimising their own costs. They can do this in two main ways – by bearing down on the lifetime costs (i.e. installation and maintenance) of infrastructure, and by minimising the cost of the energy input. The latter can be achieved in two ways – one, by reducing the total amount of energy input required (such as by insulating a home to reduce heat loss or using a more efficient heating system), and two, by delivering any remaining energy input in the lowest cost way possible. This is where the ability of HaaS models to support flexibility comes to the fore.

11 In the UK and many other countries, electricity can be sold and bought on wholesale markets by suppliers. It is traded in 30 minutes slots. As in any market the price is determined by a wide array of factors, but prominent among these are the expected level of final demand, and the cost associated with generating the electricity. Because demand for electricity in the UK is usually high during the evening peak (~4-8pm weekdays), wholesale prices are also high at this time[6]. Low wholesale prices are also associated with higher proportions of renewable generation, since the marginal costs of operating

3 Michael James Fell, "Energy Services: A Conceptual Review", *Energy Research & Social Science*, 27, 2017,129-140. DOI:10.1016/j.erss.2017.02.010.

4 Judy Osborn, Tom Furlong, and Amal Anaam, "Using the Living Lab to Sell Consumer Centric Heat Services That Encourage Adoption of Low Carbon Heating: Winter Trial 2018/19", *Energy Systems Catapult*, December 2019, **https://es.catapult.org.uk/reports/living-lab-trials-to-sell-low-carbon-heat-services/**

5 Delta-EE, "Defining Heat as a Service", October 2019, https://www.delta-ee.com/delta-ee-blog/defining-heat-as-a-service.html.

6 Nord Pool day-ahead auction prices for the UK can be seen at **https://www.nordpoolgroup.com/Market-data1/GB/Auction-prices/UK/Hourly/?view=chart**.

Time of use tariff with smart controls	Heat-as-a-service
Standard TOU tariff users may not have, or be able to afford, electric heating system with smart controls.	HaaS providers can actively install electric heating systems with smart controls in affordable way as the cost for user is spread over time.
Response to TOU tariffs relies on householders either actively choosing to change electricity usage patterns in response to pricing, or automating such changes.	HaaS providers can promote such responses directly and remotely, with no need to rely on active involvement from householders.
Shifting demand has only small cost saving potential for individual TOU users depending on tariff, likely to be of limited motivational value for many.	HaaS providers have a stronger motivation as they benefit from the aggregation of all the small shifts they are able to effect, which can make a substantial impact on profitability.
TOU has an implicit 'compromise' framing, suggesting a trade-off for householders between price and what their preference would otherwise be for use of heating (or doing other electricity-using activities).	The central HaaS offering is a non-comprised service regardless of what flexibility-related actions may be taken behind the scenes by the provider, potentially increasing its attractiveness to users.

Table 1: Reasons for superiority (in principle) of HaaS in comparison to TOU tariffs when it comes to unlocking flexibility.

renewable plant is lower[7]. As suggested above, HaaS providers profit by minimising the wholesale cost of electricity they buy. It is therefore in their interest to ensure that, as far as possible, they operate their customers' heating systems such that heating coincides with cheaper periods (i.e. outside the evening peak, or when renewable generation in plentiful). The potential to operate the final demand technology (the heating system) in response to the state of the wider electricity system (as expressed through wholesale electricity price) is what constitutes flexibility in the context of HaaS.

12 It is worth briefly rehearsing the ways in which HaaS arrangements might in principle be viewed as superior to a more standard units-based offering from a system operator perspective when it comes to unlocking flexibility of this kind. After all, wholesale price signals can be passed on to users by other means, such as time of use (TOU) tariffs, which have been shown to prompt changes in electricity usage patterns[8].

The ideal net results of HaaS arrangements are 13
less wasted energy (as determined by a level of warm environment per unit of energy input), and more flexible and responsive patterns of interaction with energy networks – both of which are widely seen as necessary for supporting transition to a low-carbon energy system[9]. As well as these potential societal benefits, HaaS also offers features which may be attractive to customers, such as providing the assurance of comfort for a fixed monthly charge.

Because of these benefits, there is inter- 14
est amongst policymakers in the potential for HaaS. The UK Government has been supporting investigation of new heating-related business models, including HaaS, through the Energy System Catapult's "Smart Systems and Heat" programme. This resulted in the most prominent UK trial to date, which took place between 2017 and 2019 in a "Living Lab" of 100 households in four English locations. Participants were offered various heat plans, which included paying for a

7 Guy Lipman, "Power Price vs Carbon Intensity", *Medium*, April 2019, **https://medium.com/@guylipman/power-price-vs-carbon-intensity-d97ee6a70aaa**; Staffell, "Measuring the Progress and Impacts of Decarbonising British Electricity", (cf. note 3).

8 Frontier Economics and Sustainability First. *Demand Side Response in the Domestic Sector - a Literature Review of Major Trials* (London, UK: Department of Energy and Climate Change, Report to DECC, 2012).

9 HM Government, 'Upgrading Our Eergy System: Smart Systems and Flexibility Plan' (London, UK, July 2017), **https://www.ofgem.gov.uk/system/files/docs/2017/07/upgrading_our_energy_system_-_smart_systems_and_flexibility_plan.pdf.**

number of "warm hours" each week on a weekly or pay-as-you-go basis, sometimes including installation of a new heating system. Between 20 and 25 of the households opted to sign up to a heat plan each year, with key motivating factors being certainty over cost and comfort (the key reason which put people of from participating was perceived high cost). While the plans on offer did not include installation of a low-carbon electricity-powered heating system, substantially more participants in this small sample indicated they would be happy to install such a system in combination with a heat plan than without. For more details on the findings of the trial, see[10]. Because examples of recent research of this kind are still somewhat limited, there is potential utility in looking to previous experience of HaaS and HaaS-like offerings. The next section summarises this experience very briefly as a way of sketching the lineage of the Budget Warmth tariff that is the main focus of the paper.

HAAS: EXPERIENCES FROM THE PAST

15 HaaS-like models have been available for a long time. If the central element of HaaS is payment for a warm space rather than energy input, then its most longstanding use is probably in multi-occupancy dwellings with lodging arrangements. Any tenancy agreement which includes the provision of either fuel or heat directly as which does not charge by unit of use could be considered to be a form of HaaS, although they are not often described as such. For example, *The New York Supplement* of 1889 lists details of a case brought:

> "...for the breach of an oral contract to provide a family of five persons with board, and with three specified rooms as lodgings in a boarding-house, and to light and heat such rooms for a specified period, at the weekly rate of $75."[11]

16 (For further examples[12] and[13].) The same sort of incentives applies in this example, as they do today: thus the landlord might try to use as little fuel (e.g. wood or coal) as possible, while the tenant benefits from even and predictable bills. Then as now, landlords may be tempted to save costs by under-supplying heat.

17 District heating systems spread this model beyond the heating of a single dwelling. Often block or district heating systems work on a service arrangement for the infrastructure – that is, occupants pay a regular fee through rent or a service charge for access to the heat source, network, and space (i.e. their dwelling) – but still have a per unit charge for heat usage determined by a heat meter. This could be thought of as warm-space-infrastructure-as-a-service, with the actual heat added as a top-up. In such cases, the operator has little direct incentive to seek energy cost reductions through efficiency or flexibility. Alternatively, some district heating schemes operate on an unmetered basis, where all infrastructure and heat input is paid for through rent or a service charge independent of the amount of energy input to a particular dwelling[14]. This is effectively a HaaS arrangement, and

10 Osborn, Furlong, and Anaam, "Using the Living Lab to Sell Consumer Centric Heat Services That Encourage Adoption of Low Carbon Heating: Winter Trial 2018/19", (cf. note 4).

11 "Oliver v. Moore", *The New York Supplement*, vol. 6 (Eagan, Minnesota, USA: West Publishing Company, 1889), 415. **https://books.google.co.uk/books?id=HeU7AAAAIAAJ&q=lodging++board+heat+rent&dq=lodging++board+heat+rent&hl=en&sa=X&ved=2ahUKEwjNiM67kY7qAhVNQUEAHfwUDVUQ6AEwAXoECAIQAg.**

12 "A Sketch of the Life of James A. Garfield", in *History of Trumbull and Mahoning Counties*, vol. 1 (Cleveland, Ohio, US: HZ Williams and Bro., 1882), 488. **https://books.google.co.uk/books?id=MU0RAwAAQBAJ&pg=PA488&lpg=PA488&dq=lodging+arrangements+fuel+and+board+history&source=bl&ots=0_6TaDLOrz&sig=ACfU3U0ACP8Zi1infTHY1Iu4Ql_rAIdSOg&hl=en&sa=X&ved=2ahUKEwi4qbq4j47qAhVtSxUIHSxdCYMQ6AEwCnoECA0QAQ#v=onepage&q=lodging%20arrangements%20fuel%20and%20board%20history&f=false.**

13 "Reports of the Principle", in *Documents of the Ninety-First Legislature of the State of New Jersey* (New Brunswick, New Jersey: J. F. Babcock, 1867), 354. **https://books.google.co.uk/books?id=nWcZAAAAYAAJ&pg=PA354&dq=rent+lodging+board+heat+light&hl=en&sa=X&ved=2ahUKEwir94WEko7qAhUUTcAKHXTWB7MQ6AEwA3oECAAQAg#v=onepage&q=rent%20lodging%20board%20heat%20light&f=false.**

14 Anna Carlsson-Hyslop, "Past Management of Energy Demand: Promotion and Adoption of Electric Heating in Britain 1945-1964", *Environment and History*, 22, n°1, 2016, 75-102, doi:10.3197/096734016X14497391602242.; Paula

in certain countries (such as Denmark, Sweden, and Finland) paying for and receiving heat on a fixed-fee basis is common[15].

18 District heating of this kind therefore presents a rich source of past experience of HaaS and HaaS-like tariffs. However, it does not demonstrate certain characteristics which are likely to be important in countries such as the UK which currently have more limited penetration of heat networks. Most important among these is that it is all but impossible for a customer at a certain address to switch between different heat networks – they are overwhelmingly likely to have access to a single network only. The main implication of this is that payment for heat is often directly or effectively tied to rental or other address-linked service charges, rather than being offered as one among several competing options which individual customers can pick and choose between, as is the dominant energy retail market model in the UK. The importance of individual customer tariff choice, except as mediated through choice of where to live, is therefore less prominent.

19 Many technical capabilities are required to make HaaS work effectively as a business model in a distributed, competitive retail market, including the potential for the operator to control the user's heating system remotely. This is necessary so that the provider can take financial advantage of the scope to influence patterns of energy input. This was often missing in the historical development of larger scale HaaS systems. While in theory operatives could be sent out to adjust the settings on heating systems, in reality some remote method of control is necessary. In smaller geographical settings, such as a block of flats or city district, control can be achieved directly by moderating the amount of heat supplied to the building or network, which in turn limits how much users are able to extract from it. The Cyclo-control system, introduced in London to provide heating in tower blocks, relied on encoding signals in mains electricity flows to use cheap electricity overnight to charge up floor heating systems[16]. However, for any HaaS offering to be made offered across a wide geographical area, such as a whole country rather than on a network-by-network basis, a larger scale system of communication to coordinate between sites of supply and demand is a fundamental prerequisite. Such a system would in principle allow HaaS to be offered independent of rental or other accommodation service agreements. The radio teleswitch, developed at the start of the 1980s, had that potential and it was this that eventually enabled the Budget Warmth tariff.

CENTRALISED CONTROL THROUGH THE RADIO TELESWITCH

20 Since the creation of the first electricity networks, network operators have tended to seek to maximise their networks' utilisation – that is, to operate them at near to capacity at all times. This is because the more evenly the network is used, the higher the total amount of electricity that can be sold through it, increasing profitability throughout the supply chain – while also making the network easier to manage. However, operators face a challenge in that people demand energy services, and therefore electricity, at some times much more than others, resulting in peaky network usage profiles including significant periods of underutilisation, along with times when the opportunity to sell extra electricity is limited by network constraints.

21 In response to this challenge, operators have sought ways to directly influence when electricity is used in people's homes. One of these

Morgenstern, Robert Lowe, and Lai Fong Chiu, "Heat Metering: Socio-Technical Challenges in District-Heated Social Housing", *Building Research & Information*, 43, n°2, 2015, 197-209, doi:10.1080/09613218.2014.932639.

15 London Economics, "Best Practice from Denmark in Price Setting for Heat Tariffs", July 2015, **https://londoneconomics.co.uk/wp-content/uploads/2015/08/Vanguards-Best-practice-from-Denmark.pdf**; Eli Sandberg, Daniel Møller Sneum, and Erik Trømborg, "Framework Conditions for Nordic District Heating - Similarities and Differences, and Why Norway Sticks Out", *Energy*, 149, 2018, 105–119, doi:10.1016/j.energy.2018.01.148.

16 EDF Energy, "Off Peak and Electricial Heating Tariffs", January 2017, **https://www.edfenergy.com/sites/default/files/time_of_use_heating_tariffs.pdf**.

is by promoting appliances that are used when electricity use is traditionally lower, such as overnight. An example of such a technology is the electric night storage heater, which uses electricity to heat up slowly overnight, and then releases heat into a space during the day. In the UK, storage heaters were heavily pushed in the 1960s and 70s as industry sought to maximise demand while minimising peaks[17]. Their use was encouraged through the introduction of tariffs such as Economy 7, which offers a cheaper rate for electricity overnight.

22 Traditionally, storage heaters were controlled by a timer, ensuring they come on and off at the right times to take advantage of lower-cost electricity. However, this approach brought with it several problems. It was unable to account for bi-annual time changes for daylight saving, and also tended to result in many large loads all turning off and on at more or less the same time, which was challenging for network managers to cope with. It also meant there was no scope to charge up or turning off of storage heaters at other times of day or night. What was needed was a way of turning large numbers of storage heaters off and on in direct response to some central control.

23 The solution which the UK opted for was the radio teleswitch. Working with the British Broadcasting Corporation (BBC), the Electricity Council[18] arranged for an inaudible signal to be encoded in the transmission for Radio 4 Longwave (best known in the UK for its coverage of five-day long cricket test matches). Broadcast across the country, this signal could be used to tell groups of storage heaters (equipped with a radio receiver) to turn off or on remotely, and it was also used to switch between on- and off-peak electricity metering. There was now the unprecedented (theoretical) potential to control loads in a way that could make them responsive to near-real-time state of the electricity system. From the system operator's perspective this was the holy grail, promising direct influence over patterns of domestic demand. Developed at the beginning of the 1980s, the signal is still being broadcast today. (For more on the history of the radio teleswitch, please see[19].)

The introduction of the radio teleswitch paved the way for more sophisticated dynamic and load control based tariffs. In an industry (pre-privatisation) in which electricity was bought and sold through a 'pool' arrangement with substantial price fluctuations, there was a drive to find new ways to make the most of the capacity for load control. 24

At the time when interest in load management was at a high, the issue of energy affordability was gaining attention. The concept of fuel poverty, introduced in the late 1970s in the wake of the oil crisis, was on the political agenda, and specific benefit payments were in place to subsidise heating. A new communication and control technology –the radio teleswitch– came together with the challenge of energy affordability to create an environment in which the Budget Warmth tariff was conceived. 25

BUDGET WARMTH

The Budget Warmth tariff was introduced in 1985/86[20]. It was targeted at low-income, elderly customers and promised to provide them with at least one warm room at all times (between October and April/May). As part of the offer, one or more electric storage heaters would be installed in their home, controllable remotely via the radio teleswitch by the local energy board (the regional agencies responsible for supplying 26

17 Carlsson-Hyslop, "Past Management of Energy Demand" (cf. note 14).

18 The Electricity Council was the governmental body with oversight of the electricity industry on matters including efficiency, financing, research, and advising the Secretary of State for Energy.

19 Michael J. Fell, "The Radio Teleswitch: An Historical Perspective on the Roll-out of Domestic Load Control", in *9th International Conference on Energy Efficiency in Domestic Appliances and Lighting (EEDAL)*, 2018, **https://publications.europa.eu/en/publication-detail/-/publication/a270a15c-fb38-11e7-b8f5-01aa75ed71a1/language-en**.

20 Letter to J Tross (Department of Health and Social Security) from G Duley (Electricity Council), February 1986, Box Number 146/157, The National Archives (United Kingdom).

energy to customers at the time). The heater(s) would be charged overnight for long enough to ensure sufficient heating during the following day (with the possibility of an afternoon top-up if necessary), based on weather forecasts. The cost of the equipment and anticipated electricity use was spread evenly in weekly charges throughout the year. The electricity used by the heaters was unmetered, meaning that all fees were based on estimates of the amount of electricity input that would be required.

27 Budget Warmth fits almost exactly the description of the kind of HaaS services that are being developed today (see "Heat-as-a-service: what and why?"). What was paid for was a warm environment, and this was done through a regular flat fee, rather than reflecting energy input directly. The cost of installing and maintaining the heating infrastructure was included in the fee. The whole system was based around central control, and could be used to support electricity network management by filling overnight troughs in demand. Although the cost could be included as part of rent or accommodation service charge, householders could also opt for this service as a standalone product.

28 Budget Warmth was initially developed by the Electricity Council, before being taken up by certain local area boards. According to Colin Gronow, an economist at the Electricity Council, when he was interviewed as part of an oral history of the UK electricity supply in 2015, the development of Budget Warmth was primarily driven by welfare concerns:

> "There was a great deal of trouble with elderly people getting cold in the winter, and quite a storm politically about it. And after that, because of our sort of thinking about it, and I think well [...] what about them having a storage heater in their living room? [...] They've got to pay for it on a weekly basis. [...] And you pay for the units but you don't pay them as they arrive. Because most of them can arrive in December Jan Feb, you pay for it right through the constant amount per week. [...] And we arranged [...] that the pensioners when they're going in and getting their pension, they can pay the Post Office, the few pounds per week that it costs."[21]

29 At the time that Budget Warmth was introduced, a number of government-funded financial support schemes were in place to help people who would otherwise struggle to pay their energy bills. These included Fuel Direct, where bills could be paid directly through a benefits payment (this still exists today), and there was also a special support scheme known as 'estate rate heating additions' for people who lived with in district-heated buildings that were acknowledged to be hard to heat and had heating systems that were disproportionately expensive to run[22]. The energy sector was still pre-privatisation, and more closely aligned with the wider public sector. Area boards regularly reported on the challenge of providing affordable heat in their annual reports in sections relating to 'disadvantaged customers', such as the following from Southern Electricity:

> "Southern Electricity co-operated with local authorities to ensure that people at risk from cold in winter had an opportunity to benefit from «Budget Warmth». This revolutionary, remote-controlled heating scheme, which uses modern technology including radio teleswitches, provides single room electric heating to a comfortable level, day and night, from October to April. ... At the year end seven hundred customers in ten local authorities within the Board's area had «Budget Warmth» installed." [23]

30 As the New Scientist reported in 1987, Budget Warmth recipients were actually selected by the then Department of Health and Social Security[24].

21 Interview of Colin Gronow (part 9 of 9) by Thomas Lean (for *An Oral History of the Electricity Supply in the UK*). Digital recording, January 2015. **https://sounds.bl.uk/Oral-history/Industry-water-steel-and-energy/021M-C1495X0028XX-0009V0**.

22 Bill Sheldrick, "Hard-to-Heat Estates: Evaluating the Benefits of Heating and Insulation Improvements", *Energy Policy*, 15, n°2, 1987, 145-157, DOI:10.1016/0301-4215(87)90122-4.

23 Southern Electricity, "Annual Report and Accounts 1986/7", 10, 1987, The SSE Archive.

24 John Lamb, "Tune in , Turn on, Warm Up", *New Scientist*, November 1987.

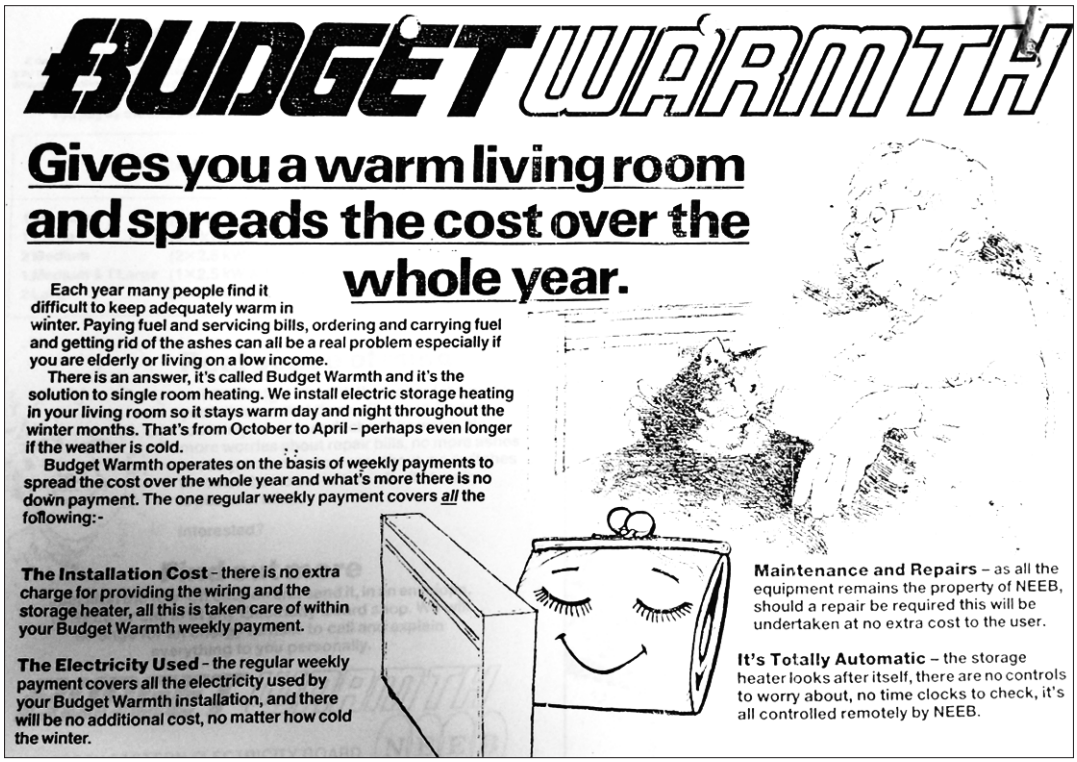

Figure 1: North Eastern Electricity Board leaflet promoting Budget Warmth (North Eastern Electricity Board, Box Number 146/157, 1986, National Archives, London)

While it was in this context – welfare – that Budget Warmth was primarily discussed at the time, its relevance for network management was also acknowledged. As the same source reports:

> "The heater is charged up at the times most convenient to the CEGB [Central Electricity Generating Board[25].] The CEGB attempts to match weather conditions with its own desire to spread demand for electricity across the day."[26], p37

31 The promotion of Budget Warmth was consistent with wider efforts to promote the growth of electricity for heating in general, particularly through the adoption of night storage heaters. North Eastern Electricity Board advertised the warmth the scheme guarantees, the spreading of cost over the year (including of installation and maintenance), and the ease of use due to its centrally-controlled nature. In addition, it addressed the "real problem, especially if you are elderly or on living on a low income" of "paying fuel and servicing bills, ordering and carrying fuel and getting rid of the ashes" (see Figure 1).

This is consistent with other industry messaging of the time that emphasise the clean and user-controllable nature of electric heating in comparison particularly to solid fuel alternatives[27]. 32

At the time that Budget Warmth was introduced, many of the target population lived in hard-to-heat buildings supplied by a district heating system. They were likely therefore in receipt of the benefit described above that was intended to subsidise their (unavoidably high) heating costs. In early 1986, the Electricity Council contacted the Department of Health and Social Security to enquire whether switching a customer to Budget Warmth (away from the estate heating system) would affect their entitlement to this 33

25 The Central Electricity Generation Board was responsible for generation and transmission of electricity across the country. Local area boards were responsible for managing distribution and were the organisations to whom customers paid their bills.

26 Lamb, "Tune in , Turn on, Warm Up", 37 (cf. note 24).

27 Carlsson-Hyslop, "Past Management of Energy Demand", (cf. note 14).

supplementary benefit[28]. The Department clarified that their benefit would indeed be affected – either being removed entirely or, if the premises itself were still considered to be 'hard to heat', reduced. The main insight from this exchange is that Budget Warmth appears in part to have been intended to attract customers to 'defect' from district heating systems. This might have made sense for certain individuals, but if fewer customers are connected to the heat network, operating costs, which are spilt between fewer parties, will rise for those who remain.

34 There were other concerns regarding the introduction of Budget Warmth. It was not universally liked by the area boards, and only six ultimately offered it to their customers. Some were worried about the unmetered nature of the supply. Colin Gronow, in an oral history interview, commented:

> "I thought he [named Electricity Council representative] was gonna love this. [...] what PR! Yeah, well, probably about half of them [the area boards] did and half didn't. And they were all of them a bit afraid, because it wasn't going to be metered. [...] if people are cheating, doing all sorts of things [...] [but] this was purely a heater with a connection through to the supply and there was no chance that they were going to do that."[29]

35 Gronow's statement hints at a wariness about introducing a disconnect between units used and price paid.

36 Whatever the pros and cons, mentions of Budget Warmth in industry literature diminish substantially after the end of the 1980s. The highest adoption figures I have been able to locate suggest that total installations were in the low thousands[30]. In the latter years of the 1980s, the tariff is consistently mentioned in the section of Southern Electricity's annual report dealing with special provisions for elderly and vulnerable people. However, following privatisation and its change to Southern Electric, there is no reference to Budget Warmth – instead this section simply deals with the provision of advice. Occasional references are made to the tariff after this point, such as in reviews of Ofgem's Social Action Plan[31], where it is mentioned as a product offered by Scottish and Southern Energy (SSE). It is listed in a 2005 article in the Daily Mirror concerning help for elderly people in cold homes[32]. In the same year, an Ofgem review of suppliers' corporate social responsibility initiatives lists the product under SSE, but states there is "no target set" (pA24) on the target number of vulnerable customers, than none were helped in 2004/5, and that 2500 had been helped since the beginning of the scheme[33]. The tariff is still (in 2019) listed as having radio teleswitch user ID and groups assigned[34], although it is not clear whether any customers are still being billed under this arrangement.

37 The Budget Warmth tariff, despite the excitement, optimism and recognition surrounding it as an innovative service offering based around new load control infrastructure, ultimately did not achieve wide success. Nor did it pave the way to a variety of other service offerings; indeed, almost all consumer energy products available since (while the exception of district heating schemes) have continued to charge on a per-unit basis. The next section considers the possible reasons for the failure of Budget Warmth.

28 Letter to J Tross (Department of Health and Social Security) from G. Duley (Electricity Council), (cf. note 20).

29 Interview of Colin Gronow (part 9 of 9) by Thomas Lean (for *An Oral History of the Electricity Supply in the UK*), (cf. note 21).

30 Lamb, "Tune in , Turn on, Warm Up", (cf. note 24); "Electricity Council Wins Technology Award", *Southern Electricity Magazine*, January 1987, The SSE Archive.

31 Ofgem, "Protecting Vulnerable Customers" (London, UK: Ofgem, January 2002), **https://www.ofgem.gov.uk/ofgem-publications/76201/1107-factsheet090201may.pdf; Ofgem, 'Social Action Plan Annual Review March 2001' (London, UK: Ofgem, January 2001), https://www.ofgem.gov.uk/ofgem-publications/57092/250-30march01-pdf**.

32 "The Cold War", *The Mirror*, December 2005, **https://www.mirror.co.uk/money/personal-finance/the-cold-war-569217**.

33 Energy Services Partnership, "Review of Suppliers' Corporate Social Responsibility Initiatives", Report prepared for Ofgem, January 2005, **https://www.ofgem.gov.uk/ofgem-publications/57153/11023-15505bpdf**.

34 Elexon, "Radio Teleswitch - Standard Settlement Configuration Mapping" (London, UK: Elexon, 2019).

REASONS FOR THE FAILURE OF BUDGET WARMTH AND HAAS MORE GENERALLY

38 Given that schemes like Budget Warmth appear to offer many advantages to providers and consumers, what explains their lack of success? In the case of Budget Warmth in particular, I believe some reasons relate to the characteristics of the service itself, and that others reflect changes in the structure of the energy industry as a whole.

39 An important characteristic of the Budget Warmth tariff is that occupants had no control over its operation. While couched in the language of ease of use, the NEEB leaflet (figure 2) states that "the storage heater looks after itself, *there are no controls to worry about* ... it's all controlled remotely by NEEB" (emphasis added). A letter from the Assistant Chief Accountant of the Electricity Council to the Department of Health and Social Security confirms that "The essential features of the Scheme are ... no customer regulation of the heater output" [35]. An early report of satisfaction with the service provided was positive, but vague:

> "There has been virtually no customer reaction to the use of radio teleswitches. The response of all districts in EMEB [the East Midlands Electricity Board] to an enquiry was that no adverse comments had been received. In fact, hardly any comments have been made by the public. In those boards where the Budget Warmth scheme is in operation, both customers and boards are pleased with the facilities and the possibilities opened up by the use of the radio teleswitching system."[36]

40 But there are also indications that success in consistently meeting the target temperature was limited. Because the radio teleswitch only provides for one-way signalling, neither the central controller not the occupant we able to recognise and respond to deviations from the target temperature. While I have not been able to identify any reports of research into target vs attained temperatures[37], minutes of a meeting between the two organisations mentioned above reveal the following information: "The system heats one room to around 20°C ... *The system maintains a broad range of temperatures in practice*" (emphasis added)[38].

41 There is more general evidence of dissatisfaction with the levels of comfort provided by electric storage heaters of the period (1980s) [39]. Their operation is quite different from other forms of heating, and lack of familiarity with how to run them in a cost- and comfort-effective way has contributed to this dissatisfaction[40], while Brunner *et al.* (2012)[41] highlight the complex considerations involved in their domestication. The introduction of Budget Warmth occurred during a period of rapid growth in central heating, from featuring in a quarter of homes in 1970 to three-quarters in 1990[42]. This was co-constitutive with an increasing expectation and ability

35 Letter to J Tross (Department of Health and Social Security) from G. Duley (Electricity Council), (cf. note 20).

36 G. O. Hensman *et al.*, "Radio Teleswitching Tariff And Load Management System", in *Fifth International Conference on Metering Apparatus and Tariffs for Electricity Supply* (Edinburgh, UK: 1987), 272-276, 276.

37 Indeed, I have not been able to locate reports of detailed consumer research on Budget Warmth from the time.

38 R. Lane, "Notes of Meeting with Electricity Council, 20.3.86", March 1986, Box Number 146/157, The National Archives (United Kingdom).

39 Consumer Focus, "From Devotees to the Disengaged: A Summary of Research into Energy Consumers' Experiences of Time of Use Tariffs and Consumer Focus's Recommendations" (London, UK, October 2012); Maria Teresa De Haro and Alison Koslowski, "Fuel Poverty and High-Rise Living: Using Community-Based Interviewers to Investigate Tenants' Inability to Keep Warm in Their Homes", *Journal of Poverty and Social Justice*, 21, n° 2, 2013, 109-121, doi:10.1332/175982713X668917.

40 De Haro and Koslowski, 'Fuel Poverty and High-Rise Living', (cf. note 39).

41 Karl-Michael Brunner, Anja Christanell, and Markus Spitzer, "Energy Consumption Practices and Social Inequality: The Case of Low-Income Households", *in* Nina Möllers and Karin Zachmann (eds.), *Past and Present Energy Societies: How Energy Connects Politics, Technologies and Cultures* (Bielefeld, Germany: Transcript Verlag, 2012), 195-220.

42 Jason Palmer and Ian Cooper, "United Kingdom Housing Energy Fact File 2013" (London, UK: Department of Energy and Climate Change, December 2013), **https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/345141/uk_housing_fact_file_2013.pdf**.

to spend time and carry out activities in multiple rooms of the home[43]. Research at the time recommended the installation of gas central heating, rather than storage heaters, to mitigate negative health impacts of cold for elderly people[44], and gas heating is generally a cheaper option[45]. Taking these factors together, when compared to the controllability and more comprehensive home coverage of gas central heating, it is reasonable to suppose that Budget Warmth may have presented a less attractive prospect.

42 Budget Warmth's relative ease of adoption may have contributed to its lack of longevity. It differed from similar offerings available at the time, such as Cyclo-control, in that it could be introduced on a dwelling-by-dwelling basis, rather than only for whole blocks. The implication of this was that individual customers may have been able to change their heating system or tariff relatively easily – in other words, the infrastructure associated with the provision of Budget Warmth was less obdurate[46]. The Barbican Estate in London was constructed to use an off-peak underfloor heating system run using Cyclo-control that gave residents similarly low levels of control. There is evidence of dissatisfaction with this system, and of people opening windows to avoid overheating[47]. However, the tenancy and leasehold agreements in that building meant that residents were simply unable to switch away from the system. The Cyclo-control system (albeit no longer operated under that name) continues to operate there[48]. The fact that such systems have continued while Budget Warmth does not is perhaps less a reflection of occupant satisfaction with service provision than of physical and legal ability to switch to another system.

43 Turning from user- to supply-side issues, another possible reason for lack of uptake and eventual decay could have been the lukewarm support given to it by the area boards. As suggested in the previous section, there were already concerns around the unmetered nature of the supply. In addition, and since the scheme was targeted at specific consumers (i.e. elderly, low-income), it was unlikely to be a major source of profit. Since Budget Warmth was often positioned as a welfare measure, the fact of its existence may have been more important than the absolute number of customers who benefited from it. Although important as a means of demonstrating innovation and commitment to vulnerable customers – what today would be termed corporate social responsibility – area boards might not have vigorously promoted its use. There is evidence of concern (with some justification) in other sectors that technology investment may be motivated more by maximising public exposure than properly commercialising the services that could be offered[49].

44 Related to this, the development of Budget Warmth may have been guided more by what was technologically possible (and economically desirable) than by close assessment of the needs of the intended user group. In 1987, Hensman *et al.*[50] said of the radio teleswitch that

43 Lenneke Kuijer and Matt Watson, "'That's When We Started Using the Living Room': Lessons from a Local History of Domestic Heating in the United Kingdom", *Energy Research & Social Science*, 28, 2017, 77-85, doi:10.1016/j.erss.2017.04.010.

44 T. Rose, W. J. Batty, and S. D. Probert, "Comparing Alternative Strategies for Achieving Thermal Comfort in Pensioners' Homes", *Applied Energy*, 32, n°2, 1989, 101-116, DOI:10.1016/0306-2619(89)90072-X.

45 Geoffrey Milne and Brenda Boardman, "Making Cold Homes Warmer: The Effect of Energy Efficiency Improvements in Low-Income Homes A Report to the Energy Action Grants Agency Charitable Trust", *Energy Policy*, 28, n°6, 2000, 411-424, DOI:10.1016/S0301-4215(00)00019-7.

46 Elizabeth Shove, Matt Watson, and Nicola Spurling, "Conceptualizing Connections: Energy Demand, Infrastructures and Social Practices", *European Journal of Social Theory*, 18, n°3, 2015, 274-287, DOI:10.1177/1368431015579964.

47 Carrie Behar, "Utilising Resident Feedback to Inform Energy-Saving Interventions at the Barbican", *Local Environment*, 19, n°5, 2014, 539-559, DOI:10.1080/13549839.2013.810205.

48 "Heating", *Barbican Living* (blog), September 2015, **http://www.barbicanliving.co.uk/flats/services-2/heating/**.

49 Robert van den Hoed, "Commitment to Fuel Cell Technology? How to Interpret Carmakers' Efforts in This Radical Technology", *Journal of Power Sources*, 141, n°2, 2005, 265-271, doi:10.1016/j.jpowsour.2004.09.017.

50 Hensman *et al.*, "Radio Teleswitching Tariff and Load Management System", (cf. note 36).

"prospects for innovative tariff and load control developments is a major source of favourable comment as well as furthering off-peak sales" (p276). Yet in 1996, Woolner and Hannon[51] observed that the radio teleswitch infrastructure had been "significantly under utilised ever since the availability of industry specifications and the widespread introduction of the system in 1984" (p20). The creation of the radio teleswitch infrastructure created an expectation and demand (in the industry) for products and services that used its capabilities. Budget Warmth met such a demand. The role of infrastructural development in contributing to new demand for, and provision of, the services they can underpin has been widely observed, including in electricity[52] and gas[53] networks.

45 Other issues contributing to the slow uptake and eventual decline of Budget Warmth and similar offers are associated with wider aspects of the structure and operation of the electricity industry at the time[54]. During the 1980s, the inability to settle customers' usage on a half-hourly basis was viewed as limiting the financial benefits that suppliers could realise through dynamically controlling customers loads, a key functionality permitted by products such as Budget Warmth[55].

46 Domestic consumers were able to switch suppliers in 1998[56], but if they did so, the new supplier was very unlikely to be aware of whether new customers had the equipment necessary to permit remote switching of the kind needed for Budget Warmth or similar solutions. Where there was no two-way communication (like that permitted by today's smart meters), acquiring relevant information would necessitate a personal visit to the property, making it (and therefore the development of tariff that depend on it) practically infeasible.

As highlighted in Wood (2008)[57], the subsequent 47
vertical disintegration of the industry meant different actors had different interests in influencing customers' electricity usage patterns. The ability to use the radio teleswitch infrastructure was split between the new suppliers and the distribution network operators – but incentives to use it differed. Supply companies wanted to make sure they were buying and selling balanced amounts of electricity, while network operators needed to manage network constraints. There was no method of coordinating between these actors to maximise value for all.

Many of the reasons why Budget Warmth failed 48
are features of this historical context. What, if anything, does this experience tell us about the opportunities and risks for HaaS today?

BUDGET WARMTH COMPARED TO THE HAAS OF TODAY

From a technological point of view, the ability 49
to monitor, control and communicate thermal conditions in homes has improved substantially since the 1980s. This is likely to be appealing both to potential HaaS customers, who are able to tailor conditions more precisely to their liking, as well as to operators, which are able to collect much richer data on their customers which can be used to inform other products and services. This is coupled with a generally more consumer-focused approach to product development, as demonstrated by the substantial social research element in recent Energy

51 L. Woolner and T. Hannon. "Demand Side Management-Latest Developments in Tele-Technology", in *Eighth International Conference on Metering and Tariffs for Energy Supply (Conf. Publ. No. 426)*, 1996, 20-24. https://doi.org/10.1049/cp:19960470.

52 Carlsson-Hyslop, "Past Management of Energy Demand", (cf. note 14).

53 Clare Hanmer and Simone Abram, "Actors, Networks, and Translation Hubs: Gas Central Heating as a Rapid Socio-Technical Transition in the United Kingdom", *Energy Research & Social Science*, 34, 2017, 176-183, DOI:10.1016/j.erss.2017.03.017.

54 Fell, "The Radio Teleswitch", (cf. note 19).

55 Ralph Turvey and Brian Cory, "Inefficiencies in Electricity Pricing in England and Wales", *Utilities Policy*, 6, n°4, 1997, 283-292, DOI:10.1016/S0957-1787(97)00029-5.

56 Peter Pearson and Jim Watson, *UK Energy Policy 1980-2010: A History and Lessons to Be Learnt* (London, UK: The Parliamentary Group for Energy Studies, 2012).

57 Janet Wood, "Silver Service", *Utility Week*, September 2008, 10-11.

System Catapult trials[58]. Half-hourly settlement for small customers is now available to suppliers on a voluntary basis (soon to be mandatory). This means suppliers are responsible for the ultimate cost of electricity their customers have actually used in a given half hour, rather than on modelled assumptions. This in turn increases the incentives to seek and unlock flexibility through products such as HaaS, by minimizing demand in high-cost periods. Given these shifts, is there anything that we can learn about the prospects or potential impacts of HaaS today from the experience of Budget Warmth?

50 Budget Warmth, which was often seen as a means of supporting the health and wellbeing of people likely to be in vulnerable situations, did not allow 'users' any control. This was done for a combination of reasons, including: to ensure that stored heat was not 'used up' too soon; to prevent people from turning down the heating and going cold[59]; to prevent levels of electricity consumption incompatible with economic running of the tariff; and to yield network management benefits. But for users, the result of this was that the effective price of a warm room and a fixed charge, was for their home to join a kind of 'flexibility factory' under the sole control of a central operator. This may be a fair trade, if expected and healthy standards of comfort are met. And there is certainly reason to believe that today's offerings would give much more priority to customer preferences. It is, for example, better appreciated that the retention of supervisory control[60] through the provision of override ability and heat top-up options as described in Osborn *et al.* (2019)[61] is an important contributor to user satisfaction. Under such circumstances there is evidence of the relative acceptability of externally controlled flexibility offerings compared to those requiring a more user-driven response (although there is a still a substantial proportion who do not find such as arrangement to be attractive)[62].

Even so, it is important to recognise that there 51
are different interests in play and that 'customers' are not always 'users'. Budget Warmth marketing material suggests that the scheme was targeted at specific households (i.e. elderly, low-income) – but often via local authorities, as housing providers (see[63]). As landlords, local authorities (and now housing associations) are be expected to act with the welfare of their occupants as a priority when procuring heating services. However, around a fifth of households today live in private rental accommodation[64], in which landlords have no such responsibility. Service-based models, similar to district heating systems, are much more likely than volumetric charging models to be rolled into a rental or service charge because of their fixed, regular nature. In such cases, while tenants are the service users, landlords become the customer – and their interests may take priority. These could include profiting from occupant data (depending on privacy terms) or allowing temperature levels to fluctuate (for instance in a building with poor thermal efficiency) in ways that have negative consequences for the occupants' health.

58 Osborn, Furlong, and Anaam, "Using the Living Lab to Sell Consumer Centric Heat Services That Encourage Adoption of Low Carbon Heating: Winter Trial 2018/19", (cf. note 4).

59 Desmond Banks, "Heating Problems: Strategy Proposal". HL Deb (11 February 1987), vol 474, col 670. **https://hansard.parliament.uk/Lords/1987-02-11/debates/3570fdab-4759-48bd-b01d-d5faab460b60/HeatingProblemsStrategyProposal**.

60 Thomas B. Sheridan, "Human Supervisory Control", *in* Gavriel Salvendy (ed.), *Handbook of Human Factors and Ergonomics* (Hoboken, NJ: John Wiley & Sons, Inc., 2012), 990-1015.

61 Osborn, Furlong, and Anaam, "Using the Living Lab to Sell Consumer Centric Heat Services That Encourage Adoption of Low Carbon Heating: Winter Trial 2018/19", (cf. note 4).

62 Michael J. Fell *et al.*, "Public Acceptability of Domestic Demand-Side Response in Great Britain: The Role of Automation and Direct Load Control", *Energy Research & Social Science*, 9, 2015, 72-84, DOI:10.1016/j.erss.2015.08.023.

63 Southern Electricity, 'Annual Report and Accounts 1986/7', 1987, The SSE Archive, (cf. note 23).

64 Office for National Statistics, "UK Private Rented Sector: 2018", January 2019, **https://www.ons.gov.uk/economy/inflationandpriceindices/articles/ukprivaterentedsector/2018**.

Figure 2: Excerpt from advert for GEC 'Nightstor' Central Heating, October 1964. Note the 'protected' heating option (GEC, 1964).

52 This suggests another area in which Budget Warmth may have fallen short. Budget Warmth was very much a supply-side solution to the problem of providing heat in a more affordable (or at least more predictably-priced) way. It did nothing to affect demand for heat, and in this respect neglected one of the key ways in which HaaS providers may profit. Indeed, in a House of Lords debate on 'heating problems' and energy efficiency in 1987, Lord Banks wrongly describe the scheme as one where "the Electricity Council will insulate a nominated room in the house of an elderly person [...] They will install heating and they will control that heating by remote control at the appropriate temperature" [65]. In fact no such insulation element was included, and indeed the exchange described earlier regarding the possible impact on estate rate heating additions suggest that there was more focus on compensating people for the heat they wasted than reducing the waste. HaaS trials today are still predominantly framed around the heating system and its controls, rather than on fabric efficiency. This has not always been so, as illustrated in promotional material from the 1960s (figure 2).

A framing based more around warmth-as-a-ser- 53
vice, with a focus on comfort, might be expected to focus on insulation. However, the failure to do so highlights another challenge for service offerings in general – that of measurement. As we have seen, Budget Warmth neatly sidestepped this issue, avoiding both metering and temperature regulation, and relying instead on calculations based on charging times. Modern HaaS offerings are much more sophisticated[66], but the measurement and control of temperature, let alone warmth, is still a challenge. For example, depending on the height above the ground at which temperature is measured, variation of several degrees Celsius can occur[67]. This means experiences of temperature can be very different depending on whether people sit or stand in a room, for example, creating potential for uncertainty around whether contracted services are being delivered. Furthermore, the pursuit of meeting minimum temperature limits combined with the desire to unlock flexibility can result in overheating in some circumstances[68]. The implication of all this is that consumer satisfaction is by no means guaranteed, even if the specific terms of a service agreement (to heat to a certain minimum measured temperature between certain times) are met. This poses new challenges for how to regulate services whose delivery is measured in the form of outcomes,

65 Banks, "Heating Problems: Strategy Proposal", (cf. note 59).

66 Osborn, Furlong, and Anaam, "Using the Living Lab to Sell Consumer Centric Heat Services That Encourage Adoption of Low Carbon Heating: Winter Trial 2018/19", (cf. note 4).

67 S. Gauthier and D. Shipworth, "Variability of Thermal Stratification in Naturally Ventilated Residential Buildings", in *Conference Proceedings: 2014 Building Simulation and Optimization Conference*, 2014, 1-7, **http://eprints.soton.ac.uk/378788/**.

68 Trevor Sweetnam *et al.*, "Domestic Demand-Side Response with Heat Pumps: Controls and Tariffs", *Building Research & Information*, 47, n°4, 2018, 344-361, DOI:10.1080/09613218.2018.1442775.

which present greater ambiguity in appropriate forms of measurement than current input-based models.

54 The parallel between HaaS offerings and district heating schemes (many of which have many HaaS-like properties) goes even further. Tenants or leaseholds in properties with district heating tend to be locked into inescapable contracts over which they have little control, and they are therefore vulnerable to being exposed to high prices which they are unable to avoid. The same is potentially true for new HaaS offerings. Where a substantial cost is involved in installing new heating equipment, distribution, controls, energy efficiency improvements, etc., and the cost of removing them again would be high, any contract associated with that offering is likely to be either quite long or to have high exit fees – or, in the case of tenants, the contract may not be possible to leave at all. (In the case of Budget Warmth, the terms in one area were "open ended with an initial year take and then one month's notice"[69].) More expensive modern heating systems such as heat pumps, or the installation of efficiency measures, are likely to require even longer periods of commitment. In Great Britain, regulation is only just beginning to catch up and provide protection to households that are locked in to district heating contracts[70]. Similar protections are likely to be needed for HaaS offerings which do not provide for easy exit, such as for tenants/leaseholders or which come bundled with expensive new equipment.

55 Finally, it is not clear that the structural and incentive issues in the electricity sector that may have contributed to the demise of Budget Warmth and other flexibility-related products have been resolved, at least in Great Britain. While distribution network operators are taking on a more active role in managing flexibility through their transformation to distribution system operators, this is still a relatively recent development[71]. While it is expected to become mandatory for domestic customers to be settled on a half-hourly basis where possible (i.e. where a smart meter is fitted), this is not the case at the time of writing[72]. This means that electricity suppliers have no strong incentive to attempt to influence electricity usage patterns in the ways that HaaS could permit. Until these and other structural incentives are addressed, HaaS is likely to remain a relatively niche offering.

CONCLUSION

56 In this article I have described the heat-as-a-service business model and shown how it might be used to unlock flexibility in electricity demand. I then considered the case of a commercial example of HaaS from the 1980s, the Budget Warmth tariff. Primarily framed as a tool to support low-income elderly customers, it was designed to provide reliable warmth in one or two rooms, based on remote control via radio teleswitch, with a flat weekly fee to cover equipment, installation and usage. While was adopted in thousands of homes and was trumpeted by the local area boards which offered it, after just a few years it was no longer actively promoted. HaaS, at least in this form, did not prove to be a success. I suggest this was due to a combination of user-related issues (such lack of controllability) and structural changes in the industry which meant that demand-side flexibility and welfare considerations became lower priorities.

69 Lane, "Notes of Meeting with Electricity Council, 20.3.86", (cf. note 38).

70 Department of Business, Energy and Industrial Strategy, "Heat Networks: Building a Market Framework" (London, UK: Department of Business, Energy and Industrial Strategy, January 2020), **https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/878072/heat-networks-building-market-framework-condoc.pdf**.

71 Ofgem, "Position Paper on Distribution System Operation: Our Approach and Regulatory Priorities" (London, UK: Ofgem, June 2019), **https://www.ofgem.gov.uk/system/files/docs/2019/08/position_paper_on_distribution_system_operation.pdf**.

72 Ofgem, "Electricity Retail Market-Wide Half-Hourly Settlement: Consultation" (London, UK: Ofgem, June 2020), **https://www.ofgem.gov.uk/system/files/docs/2020/06/mhhs_draft_impact_assessment_consultation_-_final_-_published_17_june_2020.pdf**.

57 The HaaS offerings of today, while sharing the same basic characteristics of Budget Warmth, also differ from it in important ways. Principal among these are the richer data they base their operation on, and the more thoroughgoing user involvement in service design. Nevertheless, challenges to the HaaS business model that were faced by Budget Warmth remain. These include the long contract periods required to recoup high upfront equipment costs, and enduring lack of incentives to provide demand-side flexibility. If and when HaaS offerings are offered more widely, similar challenges will be faced in balancing their potential to provide affordable warmth with risks of lock-in to unfavourable contract terms, and managing potential tensions between occupant comfort and wellbeing and operators' economic interests.

58 On the face of it, the idea of selling energy services has attractions for both system users and operators. The former can benefit from expensive new technologies and confidence in a specified measure of service (e.g. room temperature) for the comfort of a fixed regular fee. The latter get to extend their influence into the operation of domestic loads, making it easier for them secure changes in demand levels when needed. Drawing on historical accounts of Budget Warmth I have highlighted a number of practical obstacles to the smooth functioning of such models. It is also useful to question the fundamental assumptions embedded in service-based models. Budget Warmth promised a warm room at all times, while modern offerings offer 'warm hours' or other similar measures of service. These framings serve the purpose of locking in expectations of what acceptable levels of warmth are, and reproducing the view that the condition of warmth is best provided through heating, perhaps through building efficiency, and not all through other means such as activity or clothing. In this way these schemes reinforce a reality in which a certain size of electricity system is needed to furnish these expectations, and in which a degree of flexibility is needed to help manage them.

59 The electrification of heat (combined with the decarbonisation of electricity) is a key cornerstone of many cool and temperate countries' decarbonisation plans, and in this paradigm, HaaS has the potential to play a key role. The example of Budget Warmth serves as a reminder that the hurdles energy service-based business models have to get over have a longer history than is usually recognised, and that there is much to learn from the relative failures of the past.

APPENDIX A: RESEARCH APPROACH

60 This paper is based on desk-based research. This section briefly describes the process followed to identify and draw on material relating to the Budget Warmth tariff. While I did not define precise inclusion or exclusion criteria, I sought to identify as much material as possible that mentions the tariff. I conducted online searches for the terms "Budget Warmth" or "radio teleswitch" (in quotes to identify the entire phrase) on the following websites:

- Google
- UCL Explore (University College London library catalogue)
- UK Parliament
- Gov.uk (the UK government website)
- Scopus
- Web of Science
- IEEE Xplore
- The IET library catalogue (available to members and onsite)
- The SSE Heritage Collection

61 Generally search results were quite limited in number, especially when searching only for "Budget Warmth". I read through returned search results and downloaded any which include more than a passing mention (such as a line in a spreadsheet listing of tariffs) to the reference manager Zotero. One result was for an oral history interview, of which I transcribed the relevant section.

62 I also conducted archival research. I searched the catalogue of The National Archives using these and a broader range of search terms that my existing material suggested was most likely to identify relevant boxes (such as ["department of health and social security" heating]). I then hand searched 11 potentially relevant boxes for any mention of the tariff, and photographed relevant pages. I reviewed catalogues of the archives of the Electricity Council and the Central Electricity Research Laboratory, but no relevant material was identifiable and more detailed searches were not possible given the resources available for this project. I engaged with the librarian of the SSE Heritage Collection who was able to share with me a number of relevant documents, and I was also able to download all documents from the most relevant years (1985 to 1990) in order to perform keyword searches for "Budget Warmth" offline in Adobe Acrobat Professional. (Full access to documents from the SSE Heritage Collection appears to no longer be available.) Finally, I searched my own small archive (which includes one of the advertisements reproduced in this article). I read through all material and extracted details relating to the Budget Warmth tariff, then categorised these thematically to inform the discussion presented here. Additional references were identified through checking of reference lists, informal searches, and my own reference archive.

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