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Divergent imaginaries? Co-producing practitioner and householder perspective to cooling demand response in India

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A B S T R A C T

With the rise in cooling demand and the permeation of decentralised renewable energy resources in electricity networks, electricity demand-side management (DSM) has become a major tool for electricity planning and decarbonisation in the Global South. In India, the commercial application of DSM is not new, yet utility-driven residential-scale demand response (DR) remains an unexplored area. This paper contributes on two fronts – to explicate householder and practitioner’s perceptions of DR: disjunctions between these perceptions and its implications for the acceptance of residential DR. Using a co-production approach, this paper draws insights from two sets of stakeholders in India - 25 DR policy and utility experts and 24 household consumers. Our results show that technological saviourism pervasively underscores practitioners understanding of DR and householder agency, a crucial factor in the adoption of DR at the residential scale remains a missing piece. The paper concludes that without considering householder agency, delivering a decarbonised future based on demand response will be challenging and consumers may remain locked into-existing socio-cultural practices that negate the adoption of DR.

1. Introduction

Across the globe, electricity systems are undergoing profound transformations due to a multitude of needs — such as tackling climate change, guaranteeing energy security, and reducing carbon emissions. In the Global South, electricity systems are fast-changing due to the influx of distributed renewable energy sources in the electricity network and the magnitude of demand from cooling (Biardeau et al., 2020). In India, cooling, in particular, poses a significant challenge for electricity networks and, so far, there has been little progress in mitigating its effects on the overall electricity infrastructure (IEA, 2020). Presently, space cooling represents 10% of total electricity consumption, yet, with grid inefficiencies, electricity distribution companies struggle to meet peak electricity demand (IEA, 2018). With the anticipatory effects of population growth and affluence, coupled with the projected increase in temperature and boom in the uptake of air conditioning, cooling demand in India is expected to increase exponentially by 2050 (IEA, 2020). Efforts by public and private actors to chart new service pathways for cooling efficiency in India has led to the deployment of several cooling policies, rapid installations of star-rated (energy efficiency rated) air conditioning units (ACs) and local adaptation of buildings to new climate realities (Chandel et al., 2016). The forecasted implications of rising cooling demand on India’s electricity infrastructure has in recent years led to accelerated deployment of demand-side management (DSM) policies which have largely been restricted to measures associated with energy efficiency. There is a growing awareness that mitigating the impact of increased cooling demand will require extant DSM policies to be augmented with residential Demand Response (DR) initiatives.

DR can be defined as a process that facilitates changes in electricity demand in response to an incentive or signal from an electricity supplier or network operator (Darby and McKenna, 2012). The effectiveness of DR lies in the enrolment of the consumer and the renegotiation of their role from a passive user to an active energy manager. Several studies from the European Union (EU) and the United States (US) have attempted to unpack this enrolment and negotiation process. Key themes from such research include environmental and financial

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motivations underscoring user engagement with DR; the role of technological familiarity and trust in shaping user’s acceptability of DR; perceived risk around the loss of control; complexities and expectations around the DR; and user practices and routines [see Parrish et al., 2020’s systematic review on consumer engagement in DR].

Strikingly, this body of research have been dominated by the assumption that consumers might adapt to better behaviour by responding to environmental or social incentives or innovative price tariffs. This is firmly rooted in the notion that users transition from passive to active consumers will be smooth once the incentive for change is rationally appealing. However, Strengers (2014) argues that constructing consumers as ‘responsive economic agents’ or ‘resource man’ undermines the socio-behavioural and aspirational realities underpinning people’s electricity consumption. Furthermore, as seen from Parrish et al. (2020) review, empirical evidence on DR remains largely from the Global North where the model of utility ownership is different from that of the Global South where there is still a strong influence of the government on how energy systems operate. Thus, applying these assumptions to the Global South may lead to an underestimation of the socio-cultural, behavioural, and institutional sunk costs attached to utilities and electricity infrastructures in these climes. To adequately capture these socio-aspirational, institutional and behavioural dimensions, DR programmes must be designed using co-production approaches as this allows the mobilisation of knowledge from different scientific disciplines and diverse societal stakeholders with practical and lived experiences of energy systems (Skjølsvold et al., 2018). Yet, with the exception of Goulden et al. (2018) research into the co-production of DR policies remain limited, especially around householder’s and practitioner’s perceptions and expectations around DR.

Based on the above gaps, the aim of this study is twofold: first, to analyse householders and practitioner’s perception of DR and second, to assess where these perceptions merge and diverge to understand its implications for residential acceptance of DR in India. Our analysis is guided by the many DR debates within the Science Technology Studies (STS), socio-technical transition studies and this research contributes to these streams of literature in three ways. First, it probes the competing imaginaries underpinning the development of DR in India by unpacking policy, market and householders’ perceptions on which structural arrangements and social approaches will be useful in driving the acceptance of DR in India. Second, we demonstrate how DR as a service can be influenced by consumer practices and agentic capacities to shape how DR becomes appropriated or embedded. Finally, this study contributes to recent calls (Chilvers et al., 2018; Geels, 2020) to move away from the dichotomy between the technical and social by focusing on the ‘the complexities of emotions, normativity and habituations that shape the human experience’ in relation to the socio-technical environment.

Empirical insights presented in this paper are based on outputs from an international workshop with energy practitioners in Delhi and a co-production workshop with householders in Auroville in March 2020 to explore the imaginaries surrounding residential DR in India. The analysis also draws on complementary studies in the literature and a review of DR policy space in India. In the next section, we outline existing scholarship and critiques on household engagement and acceptability of DR. In section three, we provide an overview of the current state of DR in India and describe our methodology. Section four provides an overview of how domestic DR is expected to evolve in India by drawing on the workshop discussions by energy practitioners in India. Householder’s perception and imaginaries around DR are also presented. Subsequently, we assess where these imaginaries meet and diverge, and discuss its implications for DR acceptance among householders in India. Finally, the study concludes by reflecting on the challenges faced in co-producing DR imaginaries and the implications of findings for industry and policy.

2. Co-producing demand response policies: insights from science technology studies and socio-technical theories

Energy services such as cooling are socio technical as they are connected to established energy infrastructures, industries, competitive market settings, practices and rules. The introduction of demand response policies compels a reconfiguration of this socio-technical system to accommodate new adjacent technological and social innovations such as smart metering systems, automation and Information and Communication Technologies (Geels et al., 2018). Over the years, the field of science and technology studies and theories of socio-technical transitions have enriched our understanding of this process by addressing technological and societal complexities underpinning such transitions and the difficulties associated with predicting the outcomes of policies like DR (Ozaki, 2018; Powells et al., 2014).

Socio-technical scholars typically focus on how technology and user adjustment occur and co-evolve (interactions between technologies like home-displays and domestic practices) to generate insights about the ‘co-construction’ of technologies and user practices as they extend through time and space (Geels et al., 2018; Sovacool et al., 2019). Practice theory proponents who consider energy related consumption to be situated in the locus of the social argue that outside of the domestic space, co-located and loosely connected ‘bundles’ of actor(s) practices within wider institutional, socio-cultural and political spaces must be explored as these also determine how energy consumption practices occur and change (Higgison et al., 2014; Shove and Walker, 2014; Walker et al., 2014). Like the ‘practice turn’, some approaches within the socio-technical transitions literature have emerged to deal with aspects of public acceptability and deliberation. Such empirical insights are essential for DR programmes as they highlight the importance of citizen engagement in ensuring acceptability of new technologies and behavioural change (Buchanan et al., 2014; Hargreaves et al., 2013; Wolsink, 2020).

Science and technology studies (STS) have inspired a renaissance on citizen engagement and participation in energy demand research by redirecting socio-technical studies to focus on cultures, discourses, institutional arrangements and wider politico-economic spaces actors refer to mobilise public engagement in the production and construction of energy policy (Chilvers et al., 2018). According to Jasanoff (2004), scientific knowledge is embedded in social discourses, identities, norms and institutions and by examining natural and social orders as being co-produced. This reduces the tendency to assign experts critical role in policymaking while treating laypeople as passive adopters of policies and overlooking their agency and capacity to shape policy outcomes. Here, co-production of knowledge or policy is viewed as a product of social work as ‘nothing occurs in the science-policy interface without parallel adjustments in culture, society and politics; equally, social problems are rarely resolved without changes in the prevailing structure of knowledge’ (Jasanoff, 2004).

Policy co-production is a well-established approach that is useful in dealing with policy quandaries like changes in energy systems, as it stimulates the elicitation of local knowledge and systemic thinking among stakeholders to engineer the desired system change (Skjølsvold et al., 2018). With co-production, practitioners, citizens, as well as local-collective actors like consumer organisations, firms and social movements are key actors with practical knowledge of current energy infrastructures. These actors form ‘web of connections’ or what is termed as ‘networks of participation’. Co-production can stabilise, destabilise or enrol other human and non-human artefacts in collective participatory policy efforts (Chilvers et al., 2018). While such collective participation may reduce opposition to technological and policy change, they typically generate questions around trust and agency. Individual agency and control are critical aspects of DR and have become the subject of a booming body of literature in the UK and Europe, especially around the barriers to DR acceptability (Goulden et al., 2014, 2018). A common theme from these studies was that householders developed anxiety
about privacy and the potential loss of control when confronted with the adoption of DR measures (Darby and Poscia, 2013; Mert et al., 2008). While the concept of agency and the role of the householders in DR generates exciting debates, it remains unclear how to deal with these issues within the scope of citizen engagement and policy co-production. A starting point is to understand the imaginaries that shape both householders’ and practitioner’s perception of DR, followed by an identification of the forms of agency negotiations and settlements that can reconfigure household practices to align with DR needs. Thus, using India as a case study, we explore these issues through a series of co-production workshops to engage householders and DR experts in India. In the next section, we provide an overview of DR in India’s energy landscape, present our methodology and findings.

3. Methodology

3.1. Case context: DSM and DR in India’s energy policy landscape

India’s rapid urbanisation, industrialisation and population growth have made it one of the fastest-growing economies in the world. As the third-largest economy in the world, most of its industrialisation efforts are in energy-intensive sectors creating a boom in the demand for electricity services (IEA, 2020). The benefits of managing energy demand were recognised by the Government of India (GoI) and this led to the creation of the Energy Conservation Act in 2001, and the formation of the Bureau of Energy Efficiency (BEE) to develop and implement energy efficiency programmes across India (Harish & Kumar, 2014). Anchored on these two institutional frameworks are several energy efficiency programmes such as the Perform, Achieve and Trade (PAT) program for industries and the Energy Conservation Building Code (ECBC) for buildings. The GoI also created a government joint venture (Energy Efficiency Services Limited) to implement market-oriented efficiency programmes like the Super-Efficient Air Conditioning programme which encourages consumers to buy super-efficient ACs that are touted to reduce cooling costs by 50% (IEA, 2020). Further investment is required in these energy efficiency led DSM measures to mitigate projected increases in electricity demand over the next three decades (Chunekar and Sreenivas, 2019). Without these, India would need to invest USD 304 billion in grid generation to meet the expected demand from the over 1 billion air-conditioning units that are projected to be installed by 2050 (IEA, 2018, 2020).

There is a growing interest in the literature and in policy discussions to extend DSM approaches in India to include residential DR, linked to AC usage. This can potentially offer an array of benefits to both network and consumer that include reduced peak generation requirements, improved generation and network asset utilization, reduced distribution network reinforcement requirements, improved affordability and system reliability (Macpherson and Stoll, 2020). However, there are currently no DR programmes for householders who consume a third of India’s total electricity consumption. To explore how a DR process might be engineered, we take a policy co-production approach to understand the perceptions and the suite of household negotiations that will drive India’s DR policy space.

3.2. Towards the co-production of DR policy in India

The extant studies on DR tend to follow traditional methods like survey or qualitative interviews. The adoption of policy co-production method is a much-needed deviation in enriching the domain for several reasons: (1) the co-production/participatory workshop approach provides granular access to diverse actors needs across India’s electricity system; (2) the workshops’ scenario visioning exercises provides a detailed and imaginative approach to model sectoral actors DR needs and co-generate pathways to system change; (3) it is valuable for householders and systems operators as they are able to co-define and negotiate system boundaries, identify a variety of unexpected behaviours that might arise due to system change, and understand which pathways will be adaptable and resilient towards desired and undesirable futures.

In this study, we present two different types of co-production approaches taken to understand householder and practitioners’ perceptions of DR in India. First, through facilitated workshop discussions, we probe DR experts’ understandings of household ability to shift to DR and identify current and future building and network needs. Second, through a series of scenario-based co-production workshops, we explicate household views around DR, identify core areas of agency negotiations and its consequences for DR policy in India.

3.2.1. Practitioners co-production: workshop

The workshop is different from conventional focus group discussions as it involves trans-disciplinary knowledge and expertise around DR with the objective of translating this knowledge to policy. As with the methodology of workshops, we started with discussions around preliminary findings with the hope that participants might collaborate in the evolution, exchange of knowledge and development of solutions. To understand practitioners’ imaginaries around DR, a one-day workshop was held in Delhi in March 2019 with n = 25 people from four practitioner categories: (i) academia (n = 13), (ii) representatives of local utilities (n = 2), (iii) policy think-tanks (n = 6), and (iv) regulatory actors (n = 4).

Participants were invited based on their expertise, knowledge and experience of India’s electricity networks and the built environment. An open dialogue approach was adopted, which allowed participants to share lessons from their current work on India’s grid and the built environment. Core areas discussed during the first informative session were electricity consumption monitoring, appliance ownership and demand side-management.

In the second part of the workshop, participants were asked to focus on both current and future challenges especially, around how to implement DR strategies at the building and network level. Three questions guided this phase of the workshop: what are the core challenges around the implementation of energy demand flexibility policies for residential buildings in India? What are the key issues currently affecting India’s local electricity networks? What changes might come into the picture in the next few decades, and how do we address these? Answering these questions, participants identified multiple variables influencing DR at the building and network-level, especially in relation to the future impacts of cooling on the grid. The workshop lasted for an entire day and discussions were recorded with consent from all participants. Key themes from the discussion are analysed in the results section.

3.2.2. Householder co-production

To understand householder imaginaries around DR, a two-day co-production workshop was held in Auroville in March 2019 with n = 24 people. Fifteen people participated on the first day and eleven people participated on the second day. Participants represented five categories of expertise: (i) Auroville think tank (n = 6), (ii) representatives of Auroville local utilities (n = 5), (iii) members of the town development committee (n = 5), (iv) regulatory actors (n = 1), and (v) Householders with no prior knowledge of DR (n = 7). The co-production exercise was divided into three discursive phases over a three-to 4-h period. The first phase involved discussions with participants on responses generated from a previously conducted survey with householders in Auroville on their willingness to shift to DR measures such as time of use tariffs and automation. Displaying the results from the survey, participants were encouraged to discuss why others (including themselves) in the

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1. AVC is a consulting company which works on sustainability experiments in India. They currently serve as the data provider and contact person for the CEDRI project in Auroville.
community were resistive to the idea of automation, especially for cooling. In the second discursive phase, participants were introduced to numerous DSM strategies and shown a demand management matrix (see Appendix A). They were asked to identify where they were on the matrix, where they would like to be and discuss barriers to this shift. They were asked to repeat the matrix exercise for their community and discuss their perceptions of how energy practices will be altered based on this change (situating the discourse within the practice theory). In the third discursive step, the second author presented a series of DR cooling flexibility options generated from existing literature and examples of DR in EU/US context (see Fig. 1 for a summary). These options were presented in lay-terms (as seen in Fig. 1) to help householders understand the proposed flexibility policies as flexibility was quite an abstract construct to many householders. Participants were placed in groups, and through a scenario-based exercise, asked to create a DR cooling policy for the Auroville community. Participants were to choose the DR options they were most comfortable with; provide incentives that could increase the uptake of the preferred DR option, identify possible barriers to the adoption of their preferred option and identify supportive stakeholders needed to ensure that their chosen DR policy works. Also, participants were given the freedom to propose their own DR policy if the options provided did not suit them.

The scenario exercise was conducted to understand householder preferences, identify core areas of agency negotiations and develop future pathways of DR co-creation in India. Transcripts from the co-production exercise were coded thematically in NVivo software. Using a thematic analysis (Braun and Clarke, 2006; Robson, 2002) the data was first inductively coded by (i) participants views around DR measures such as automation and time of use tariff (ii) willingness to shift to DR measures and (iii) opportunities and barriers to shifting to DR strategies. The data went through a second iterative step and was deductively categorised according to the four cooling flexibility functions set out in Fig. 1. Themes around the opportunities and challenges that may emerge per each flexibility function were coded and are highlighted in Table 1. Although our analysis of the workshop discussions is limited to the Indian context, they still demonstrate a range of householders’ perception and energy planner’s responses to DR. In the next section, we discuss findings from both practitioners and householders.

### 4. Results

The results of the two streams of co-production workshop are presented separately below. In the first part, we engage with themes discussed by practitioners. In the second part of this section, we discuss issues raised by householders as critical barriers and enablers to the

| Table 1 | Summary of cooling flexibility options and attributes. |
|---|---|---|
| **Flexibility options** | **Flexibility name** | **Flexibility attributes** |
| Option A | local | • No external influence on the operation |
| Option B | Aggregated | • Thermal comfort MUST be delivered, but aggregated control seeks to reduce lots of AC systems being on at once |
| Option C | Relaxed | • ON setpoint temperature is relaxed by 2°C |
| Option D | Interruptible | • The interruptible tariff allows AC to be switched off during specific times of the day – say 2 h, say between 16h00 and 18h00 – different for different dwellings |

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<table>
<thead>
<tr>
<th><strong>Findings from scenario analysis</strong></th>
</tr>
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<tbody>
<tr>
<td>• Not considered as an option</td>
</tr>
<tr>
<td>• Preferred over relaxed option by those who already use ACs at higher temperature settings.</td>
</tr>
<tr>
<td>• Seen as favourable for some as it reduces the behavioural responsibilities of householders; lessens the effort required to use ACs efficiently and reduces guilt when expected pro-environmental use of ACs are not met</td>
</tr>
<tr>
<td>• Seen to mitigate the detrimental effects of unsustainable AC consumption at the community level.</td>
</tr>
</tbody>
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Fig. 1. Cooling flexibility options presented to participants in Auroville.
acceptance of DR in India.

4.1. Practitioners perspective

The practitioners’ knowledge co-production in Delhi revealed several key issues crucial to the implementation of DR in India. Issued raised were centred on current and future challenges at the building and network-level with respect to implementing household DR strategies in India.

4.1.1. Current building level challenges

Framing current building-related barriers to residential DR in India, practitioners identified three key themes: (a) behavioural and knowledge constraints; (b) techno-cultural inertia and (c) capital and operational cost dynamics of efficiency solutions. The emergence of these themes was not surprising as research has shown that policy actors and practitioners tend to default to policy instruments that targets or prioritises individual behaviours (Goulden et al., 2018).

Discussing behavioural concerns about residential DR, there was a widely held view that Indian householders had limited knowledge about their load profiles (e.g., the difference between critical and non-critical load) which in turn, affected the adoption of energy efficiency measures. The knowledge vacuum is attributed to the absence of communication conduits through which reliable information about efficient technologies or practices gets to householders. As described by a utility representative: “Awareness about energy efficiency remains a big problem. It has not reached the consumer.”

Practitioners argued that for behavioural change to occur, supporting infrastructures such as smart metering systems must be made available to householders. With smart meters, it is envisaged that utilities will be better equipped to deal with issues of power theft and electricity hardware pilferage. Real-time information on electricity consumption will also presumably transform previously passive consumers into energy-conscious managers. Yet, studies have shown that such optimism about feedback can be misleading as there are socio-cultural dynamics that influence the extent to which feedback is used (Martin, 2020).

The issue of techno-cultural inertia emerged as another concern, and several factors were identified as being responsible for this. Firstly, a measure of functionality is attached to existing technologies. This creates a general feeling that ‘if it isn’t broken, it should not be replaced.’ As described by one Practitioner: “There is inertia with human beings. I have a ceiling fan traditionally running for fifteen years. It is throwing a good amount of air, and I’m pleased. I do not want to replace it, even if I have a 28-W one in the market. There are equally people who have AC for 10-years in a row. Every year what they do is they get their gas-filled to get it going. So, the inertia is very, very huge.” Secondly, practitioners believed that the emotional and social values (status symbols) attached to appliances like ACs will shape how people respond to DR. They argued that the adoption of ACs in metropolitan cities like Delhi has become pervasive due to its construction as a symbol of affluence and sophistication.

Capital and operational cost dynamics of efficiency solutions emerged as a prominent barrier to residential DR. High investment costs with a longer payback period were found to disincentivise householders from making efficiency investments. For example, practitioners described how cost was a huge factor for consumers in the government 7-star AC programme (a 5-star AC is the most efficient AC in the Indian market, the introduction of a 7-star AC means better efficiency). “It was not a very successful programme because the number of units which was sold, there are multiple reasons for it. i) the price point, if you compare that model with other 5-star model ACs in Delhi for example, the payback period for the incremental costs that you’re paying for that 7star AC is ten years.” Practitioners further agreed that while the idea of a government-backed 7-star AC was appealing, the programme lacked a replacement scheme where older ACs could be traded in for a 7-star system; there were no financial incentives to encourage householders to make an expensive investment and when compared with other lower star rated ACs in the market, the product’s payback time was longer.

4.1.2. Future building level challenges

Practitioners envisaged three future challenges around household DR in India; (a) regulatory and policy shift on residential buildings and appliances; (b) technological deployment and development of supporting business models and (c) technology management and skills building.

The formulation of long-term visions and policies that guide the conduct of system actors, institutions as well as users were identified by practitioners as pivotal in shaping the direction of residential DR in India. There was a call to improve the Energy Conservation Building Code (ECBC) as this is currently limited to new builds leaving existing residential buildings which make up a considerable chunk of the building mass un-catered to policy-wise. Questions were posed to practitioners as to whether the new ECBC should be adopted at the state level and translated as a core part of the building permit process to encourage the adoption of passive measures to reduce cooling load. Most practitioners were of the view that the ECBC should be implemented at the state level to include existing build as this will drive the market for energy-efficient appliances and products especially as householders become affluent and per-capita consumption of electricity increases. However, they caution that such appliance shift would require stricter transitional or disruptive regulations around existing appliances. One of such proposed regulations is a policy mandate that “prohibits the use of all non-star rated ACs which currently make up the bulk of ACs used in India. This requires a gradual phase-out of inefficient ACs and must be captured within the scope of a circular economy process to ensure that inefficient ACs are indeed removed from households and not rebranded as efficient ones.”

Technological deployment and the development of supporting business models were seen as necessary for the development of residential DR. According to both utility representatives, systems operators need tools to guide them in creating solutions that provide more flexibility, guarantees occupants comfort and ensures low energy use. They advocated for the normalisation of tools like Residential Building Management Systems and sensors combined with occupancy evaluations to enable the quantification of performance-behaviour relationship that can be fed into modelling tools to inform decision making for future electricity demand scenarios. It was suggested that the business value of these technologies would open up new spaces of collaboration among different types of actors (energy service operation companies (ESCOs), Distribution Companies (DISCOMs) and architects) who will be critical to the aggregation of energy use at various stages of the building life cycle. As described by the utility representative “the deployment of supporting incentives to promote such technologies will be crucial to the business models of ESCOs and DISCOMs, and this is where collaborations with banks and other market players who offer zero cost interests will effectively minimise investment costs associated with these low-carbon building technologies.”

Practitioners further surmise that as ECBC and DR related innovations become dominant, the proliferation of skills to support new technologies will be crucial for optimal operational actions around automation. They argue that householders with no prior familiarisation with thermostat setpoints or other Internet of Things (IoT) tools that support building efficiency will struggle with these innovations. Thus, the availability of skilled engineers and technicians guiding householders on these issues will facilitate consumer adoption of DR.

4.1.3. Current system-level challenges

At the system level, two themes were seen as currently critical for household DR; (a) addressing metering infrastructure limitations and disparities between urban and rural electricity connections and (b) collaborations with research institutes to analyse ever-growing utility datasets. Practitioners identified the need for system managers to provide metering infrastructure for both urban and rural users. It was suggested that such infrastructure should be bundled with the GoI’s last-
mile electrification policy in rural areas and should be supported with user education. Utility actors further stressed that system-level data is hardly analysed for load forecasting, load shapes and changes in load profiles, nor is it utilised for robust energy planning. Thus, they called for utility collaborations with technical research institutions as this can lead to the development of localised modelling and simulation tools required for the quantification of behavioural impacts on energy use. Accordingly, such data-driven analytics is needed to provide information on household energy demand; develop metrics on consumer satisfaction and demonstrate the economic significance of user-centric design in accelerating the acceptance of DR programmes or policies.

4.1.4. Future system-level challenges

Future system challenges discussed can be categorised into four themes; (a) large penetrations of Photovoltaic systems (PVs) and Electric Vehicles (EVs) creating grid management issues (b) the role of energy storage (c) making residential energy efficiency as a dispatchable resource for the network and (d) democratising the energy system to foster consumers transition to prosumers. Practitioners commented that low power quality issues, currently common in rural areas are becoming apparent in urban areas because of the growth in rooftop solar and the transition to 100% LED lighting. Whilst these issues have been anticipated by regulators, the attendant policies have not been implemented. In future systems, these emergent power quality issues will be compounded by the growth in EV charging stations. A utility representative commented, “anyone can set up a charging station” alluding to the lack of regulatory oversight as to how they will be managed and integrated with existing grid management practices. This absence may mean “charging load can come anytime” leading to further deterioration in power quality and harmonics.

Reflecting on current government policies around renewables, practitioners argued for more investments in energy storage. As described by a utility actor, some DISCOMs have begun to operate hybrid solar systems. In places like the Union territory, this hybridisation has led to the creation utility level policy for renewables where subsidies are provided at 10,000 rupees per kW for up to 5 kW. While these subsidies are for PVs, it was revealed that there are plans to extend them to storage, for instance, householders can get 2kW PV subsidy and 2kW battery subsidy. Yet, it was acknowledged that more financing policies will be needed in the future for storage to adequately provide ancillary services to the grid and enhance the resilience of the network.

Concluding, their thoughts on future network requirements, practitioners envisioned a future where controlled cooling is turned to a dispatchable resource for the grid. For them, this requires the introduction of Integrated Resource Planning (IRP) which will facilitate the creation of wholesale and retail markets where operational flexibilities like balancing and capacity markets required by system operators become available to ensure grid resilience. Utility actors advocated for IRP to be owned and operated by the grid operators as ownership of these infrastructure provides complete visibility or real-time picture of the grid. “DISCOMs manage, schedule and ensure that the power is available. However, this has become problematic with the increasing penetration of renewables. Therefore, there has to be dynamic imbalance management by the system operator, and at the moment, this is currently unavailable in India. This means there is a need for a DSO which has visibility into the distribution side of demand and manages ancillary services markets”. In conclusion, India’s shift to IRP was viewed as a pathway towards the democratisation of the electricity system. Practitioners believe this will not only enable consumers to transition to prosumers but allow them to provide ancillary services to support the operation of the distribution network.

4.2. Householder perspective

In the following analysis, we explicate key themes discussed during the householder co-production exercise in Auroville. Issued raised revolved around opportunities, negotiations and barriers to DR — explicitly with regards to the willingness to shift to DR measures like automation. Furthermore, we discuss the outcome of our scenario-based policy-making exercise on potential cooling flexibility programmes that might be deployed to complement residential DR.

4.2.1. Willingness to shift to DR measures

Householders identified two main factors fuelling their resistance to automation: (a) automation strips away individual agency and capacity to choose and (b) high investment cost of adjacent Internet of Things related technologies needed to ensure optimal functioning of DR programmes.

Householders prime concern was the degree to which automation, especially with regards to ACs, would lead to the erosion of individual agency and autonomy. For some, the use of AC was seen as essential to wellness and the ability to perform work-related tasks. As such, external control of ACs was seen as non-negotiable and perceived as a threat to the individual’s locus of control. Probed further, householders referred to experiential instances of physical discomfort from the absence of ACs and how this remarkably led to inefficiencies in the performance of daily tasks. Individual’s corporeal experiences with discomfort became a site of tacit knowledge which moulded the boundaries for technological acceptance.

Others discussed the emotional aspects of automation as a barrier to the adoption of DR. Some argued that while automation might provide high-efficiency value, however, this pales in comparison to the expected loss of control over comfort. ‘Cosiness’ has emotional value, and an external override means the individual loses the control to provide these sensory effects for themselves (Madsen and Gram-Hansen, 2017). Illustrating their discomfort with automation, some participants discussed how they ‘hate centralisation as this minimises their ability to get the desired thermal conditions or cosiness at home’.

For householders who place a premium on the emotional value of comfort, acceptance or continuous engagement with DR related activities became unlikely. When the discussion on the connection between automation and time-shifting activities were presented, householders deferred to consequential impacts on changes in daily rhythms. This reifies Higginson et al. (2014) argument that agency is deeply intertwined with the rhythms of practices (be it emotional, corporeal or material) and flexibility on such matters are dictated by more complex elements that underpin the performance of these practices. Here, meanings associated with the expected shift to automation precluded householders’ expectations on which practices would be altered.

High investment cost of adjacent IoT technologies needed to enhance automation was identified as a barrier to the acceptance of automation or the flexibility that can be offered. Unsurprisingly, access to resources such as income was identified as a conditionality for acceptance as less income meant more competing household interests get prioritised over the need for new smart appliances. When questioned whether membership in a community known for its ecological values can encourage a change in perception, participants acknowledged that despite making disruptive life changes by choosing to move to and live in Auroville, financial constraints remain a determiner in how they will respond to innovations like smart appliances. Such feelings are consistent with recent research in the distributive justice and flexibility capital literature which highlights smart appliance costs as an energy justice issue as it allows certain groups of consumers to shift fluidly towards DR while serving as an inhibition to others. As described by Powells and Fell (2019) and Johnson (2020) affluent users are likely to have more flexibility capital because of their existing ownership of smart technologies whereas less affluent users are more likely to rely on changes to their daily practices to offer the flexibility needed for the grid. Yet, despite these objections or barriers to automation, householders believed that more information on how automation works could perhaps convince them of their ability to retain control over comfort. For householders, changing previously held meanings attached to ACs to accommodate new practices would require the dissemination of information about the
proposed changes, increase in know-how and the provision of legitimacy to efficiency measures by recasting it as a community effort.

4.2.2. Adoptable cooling flexibility options at a community scale

Having unpacked potential barriers to DR, participants were presented with a scenario of flexibility options and asked to design a cooling flexibility programme based on the options provided (see Table 1 for details). Of the four options presented, interruptible flexibility and relaxed flexibility were the two prominent options among householders.

4.2.3. Interruptible flexibility

Some householders’ choice of interruptible flexibility was justified with the assumption that ACs will become an essential part of the community for work and health purposes and this will invariably mean an increase in the community’s overall peak load. Moreover, while they recognised that as individuals, they might be able to manage their use of ACs efficiently, it was also acknowledged that collectively as a community, this might be difficult due to the independent cooling choices made across households. For this group of householders, an interruptible flexibility option will mitigate the detrimental effects of unsustainable AC consumption at the community level. As illustrated in the quote below, preference for interruptible flexibility over relaxed flexibility is fuelled by the concern that it would be injurious for those who already use their ACs at higher temperature settings: “If one has to choose between the two, not the relaxed one because of the 2-degree increase. An important reason is that I set my AC already at 27 degrees. So, the 2-degree increase is just not going to be viable for me. We were not sure whether the 2-degree increase would make such a big difference in the bigger picture. And it was a lot about wanting to know how the bigger picture is influenced by our choice. So interruptible was the choice that we went with.”

Similarly, householders perceived that an interruptible option would serve as an excellent model to educate others on ‘how a small decrease in individual consumption can make a large impact’. It was also seen as a means of establishing a new mindset around AC consumption within the community. Negotiating the terms of acceptability of this flexibility option, householders agree that there is a need for clear information on what the broader community consumption is in comparison with individual household consumption at peak periods. Such informational forecast is reportedly required to help householders adjust or make personal choices around when to start their ACs. Likewise, a mobile application that alerts users about peak period and leverages peer comparison will dissuade unsustainable use of ACs and might even motivate householders to self-regulate their consumption.

“So, if this 2 hours of AC is implemented and they switch off my AC for 2 hours and inform me afterwards what the impact of switching off my AC had, it would cause me to understand the idea behind it and maybe in the future implement it myself, without having a regulation to.”

As seen from the above quote, householders assume that the inclusion of informational support will improve the community’s engagement with DR. What is observed above is the heroic attribution from householders that with ‘more information’ they will be able to adjust their behaviour to suit the expected consumption patterns. Yet, evidence from recent research suggest that this is not the case as the magnitude of expected changes are dependent on other complex factors.

4.2.4. Relaxed flexibility

Householder’s who preferred the relaxed flexibility option argued that unlike the interruptible option, there is a transparent methodology underpinning the system operator’s decision on when and how ACs would be switched off. Also, since most household’s temperature settings are typically between 19 and 24°, a 2-degree relaxation would have a non-life-threatening impact on comfort. The automation feature of the relaxed option reduces the behavioural responsibilities of householders and lessens the effort required to use ACs efficiently. The shift in responsibility also reduces the guilt of the householder when expected pro-environmental use of ACs are not met.

Householders, however, acknowledged that several barriers could potentially affect the effectiveness of the relaxed flexibility option. First, the installation of control systems presented a potential challenge as most householders might be ‘suspicious’ of the program or regard it as an invasion of privacy, thus affecting the scale of uptake. Second, emotional attachment to the feeling of ‘cosiness’ might demotivate household participation in such programmes as ‘some people like to turn on their AC at 19 degrees and pull up their duvet’. Third, technological connectivity issues might lead to household frustrations around the viability or reliability of the system.

Negotiating the incentives that could potentially address the barriers, householders identified four instruments that could play a role in increasing the uptake of the relaxed flexibility option. First, pilot demonstrations with compelling data showing the effectiveness of the program will provide legitimacy and spur significant acceptance of the program. Second, the technical knowledge from such programmes can serve as a vector in understanding cooling systems control boundaries that are acceptable at the household level. It would also provide householders with clear information on appliance performance and electricity consumption patterns. Third, reduction in tariff for participating households would substantially increase the program’s attractiveness as this offers a form of economic rationalisation for participation. Fourth, most rebate programmes are usually given as kWh credits; however, householders argue that energy savings made by participating consumers should be turned to cash that can be spent anywhere (groceries or rent). As suggested by one participant: “There is no incentive to change if I can reduce my consumption from 10,000 rupees to 7000 rupees yet, I am only told of my savings with data. However, if I pay in 10,000 and given 3000 back at the end of the month, I feel like I have gained something for changing my behaviour.” It was pointed out that supporting instruments should not only be limited to financially attractive or appealing incentives; rather, supporting instruments can be positioned to match the normative orientations that underscore the daily realities and practices of the household (e.g.).

Finally, those who showed no interest in any of the proposed flexibility options recommended alternatives that had zero impact on their agency. For instance, a participant advocated for a change in supply infrastructure and suggested that ‘If the transformer can’t take the load it should be upgraded’. For this individual, any form of utility-driven cooling control was unappealing. This shows that unless persuasive narratives on the impacts of DR on grid efficiency and sustainability are provided, householders may become less disposed to adjusting their lifestyles to accommodate DR policy measures. Instead, they may prefer to stick to existing or incremental energy curtailment activities like switching off lights or using efficient appliances. Importantly, householders’ negotiations around provided flexibility options highlight the processes and institutional changes that could underpin the acceptance of DR in India. These are likely to be profound, ranging from a systematic shift in current energy governance structures to its complete dismantling and replacement by new modes of energy education and planning to set the necessary conditions to stimulate the acceptance of residential DR.

5. Discussions

India’s development of DR is currently driven by policy and industry interests, yet household perspective crucial to its deployment at the residential level is mostly missing from this picture. This study attempted to bridge this gap by unpacking how DR is characterised and perceived by both practitioners and residential end-users. In the next section, we delve into the commonalities shaping the imaginations of these actors and also highlight the contrasting visions that might potentially hinder the acceptance of DR at a residential scale.
5.1. The intersection of DR imaginaries: implications for residential-scale DR in India

5.1.1. Where imaginaries meet

As seen from the results, there is an apparent convergence in imaginaries between practitioners and householders on three core issues that could potentially shape the acceptance of residential DR: (i) consumer knowledge; (ii) techno-social inertia and (iii) investment cost.

**Consumer knowledge:** Two streams of informational needs were identified as crucial to a successful implementation of DR: information around market trends and supporting instruments from actors directly involved in DR—such as cooling service vendors or energy policy planners; and technical information and load profile analysis about consumers' current load profile, and subsequent impacts of DR on energy savings. It was acknowledged that such knowledge transfer exercise could potentially lead to feedbacks from householders who can provide programmatic or customised information based on their experiences to partially increase the tolerability for IoT appliance investment since there is additional liability that both policymakers and householders might be hesitant to escape the techno-social trap or inertia. This view is shared for profiles and its accompanying meanings at the country scale would be critical household system change and the frequency of heatwaves, ACs are slowly becoming a norm attached to the use of ACs. This is interesting because, with climate change and the frequency of heatwaves, ACs are slowly becoming a critical household system— and as a consequence, it has a different risk portfolio when compared to other household technologies. Yet, both groups of actors agree that decision-makers currently do not possess the information on the scale at which householders would prioritise the use of ACs. Thus, they argue that co-production of DR policies will be pivotal in unearthing key questions around the values and norms that motivate household investment and operation of DR enabling cooling appliances (Wolsink, 2020). Also, knowledge of changing socio-economic profiles and its accompanying meanings at the country scale would be required to escape the techno-social trap or inertia. This view is shared among socio-technical and practice scholars who argue that research into DR must focus on ‘macro-level boxes’ such as rise in per-capita income, the “cool factor” associated with AC use, and the emerging building market norms which strongly prioritises installations of ACs units in new buildings (Geels, 2020a; Lovins, 2018).

**Investment costs:** At both ends of the spectrum, it is recognised that investment costs attached to DR represent socio-economic and institutional liability that both policymakers and householders might be hesitant to take on. Yet, through our scenario exercise in Auroville, household participation in cooling flexibility programmes can potentially increase the tolerability for IoT appliance investment since there is an assurance that the utility is committed to the maintenance of installed systems and can guarantee savings and return on investment in a reliable way. Similarly, for practitioners, reduction in investment cost is seen as a means to increase household support and involvement in DR. As cost becomes lower, it is envisaged that new technological spin-off will emerge hence creating new markets and visions that could further guide household behaviours around DR.

5.1.2. Where imaginaries diverge

Despite shared imaginaries around DR, there was also a clear divergence in what practitioners considered as strategic and what householders perceived to be crucial to the acceptance of residential DR in India: (i) Technological saviourism vs agency and (ii) prosumer centric vs uncomfortable prosumer.

**Technological saviourism vs agency:** Practitioners were more focused on innovations, technologies and institutional arrangements that enhance the deployment of DR, whereas householders were focused on agency and settlements around DR. Householders were favourable towards changes that did not affect their sense of control or require reconfiguration in existing household practices. Practitioners’ neglect of the costs associated with household agency is symptomatic of the current techno-saviourism plaguing global energy landscape. The reliance on technological saviourism further came to fore with practitioners’ reference to the use of smart meters to deter theft. Such views disregard the anarchic relationship between citizens and utilities in India around metering and underplay instances where farmers have smashed up meters perceived to disrupt their access to free electricity. Nonetheless, the delegition of behavioural change to machines can indeed provide some measure of control for system managers as this allows the functioning of the system with little or no interference from human activities. On the one hand, such ploy towards consumerism can have negative impacts by driving significant rebound effects (Goulden et al., 2018). On the other hand, it is an exclusionary approach as it disfavours populations of the population who cannot afford to invest in such expensive appliances (Fowelle and Fell, 2019). Considering the socio-economic imbalance in India, the latter is likely to happen and might dawdle the expected leaps in the implementation of DR.

**Prosumer centric vs. uncomfortable prosumer:** Practitioners envisaged an electricity system which enables householders to become prosumers. This is similar to existing DR literature in Europe and North America where actors concerned with DR policymaking tend to construct householders as willing constituents for whom the benefits of being ancillary service providers for DR are obvious. Householders in India seemingly felt unprepared to take up the role of the de-facto supplier of ancillary services. Several factors may be responsible for this: (a) electricity systems in India are government-owned; (b) solar PVs are still high-priced and (c) householders are not convinced of the economic value of participating in DR programmes. This divergence between practitioner expectations and householder realities creates a problem for DR system operators as this means they are unable to create a blueprint of what range of ancillary services householders will be able to offer and for how long these services would be available. This invariably renders attempts at co-opting householders as part of the energy regime practically difficult.

5.2. Study limitations and opportunities for new research

While we have been able to unpack residential DR imaginaries by taking a co-production approach to facilitate policy-science-user dialogues around DR, however, we acknowledge that our study remains limited on several fronts. First, this research was mainly restricted to a small group of practitioners and householders and places limitations on the study’s ability to generalise findings from this study to the national context. However, a larger scale co-production research which incorporates households of different socio-economic categorisations living in different climatic regions might provide insights on previously unknown factors that might shape residential DR acceptability in India. For example, such research might provide insights on whether households in more extreme climates (Jaipur) will be open to a relaxed cooling flexibility option like their counterparts in a milder (by Indian standards) climate region like Auroville? Second, the relatively small sample adopted for the cooling flexibility scenario exercise was to explore the negotiations and settlements that will emerge when householders are requested to make changes in their daily activities due to their acceptance of DR. While this was not aimed at producing a generalisable result, we believe such small-scale experimentation might be useful for community energy planning. However, we acknowledge that this might not be enough to mainstream the acceptance of residential DR at state or city scale. Future research or experimentation must be designed at a city-wide scale as lessons from such experiments will be useful in strengthening the business and policy case for residential DR. Of course, such research would also lead to investigations around how successful alliances can be made by energy stakeholders to enable political and social tipping points around DR.
6. Conclusions and policy implications

Changes in India’s electricity landscape -such as the rise in cooling peak load has triggered new policy interests in residential demand response programmes. Using a policy co-production approach, this article investigated both householders and practitioner’s perception of residential demand response and offers strong empirical evidence on the competing imaginaries underpinning the development of DR among policy, industry and household actors in India. Our findings show three policy-relevant factors that might shape how DR evolves in India: (a) An increase in community energy initiatives and energy system decentralisation is expected as DR creates an opportunity to shift power generation from a GW/MW scale down to a kW scale and more importantly facilitate the integration of flexibility signals from storages and EV charging stations. Such scale of decentralisation may strongly incentivise householder to modify consumption patterns to aid grid reliability goals. (b) Similarly, as new business value-chains around DR related smart solutions develop, mutually reinforcing social programs will be required to effectively support DR, improve participation of both existing and new electricity actors and increase public acceptability. These incentives will also help socialise the costs of activating flexibility and enable market priority for householder with renewables. (c) Finally, revising and reframing existing institutional, regulatory and economic structures such that they become adaptable to DR will be sacrosanct. Such revision would mean shifting from a current market dominated view of DR to an inclusive system of decision making that integrates energy stakeholders who can offer best practices and advisory services on DR, support the generation of skills for practitioners, and provide clear socio-institutional guidelines on householder engagement (Baldwin et al., 2018; Goulden et al., 2018).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Electricity demand side matrix

<table>
<thead>
<tr>
<th>Technological change</th>
<th>Behavioural changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor shifts</td>
<td>Incremental shifts</td>
</tr>
<tr>
<td>Green purchases (e.g., using energy efficient fans or ACs)</td>
<td>Making significant investment e.g., installation of energy monitoring appliances such as smart meters or installation of automation technologies</td>
</tr>
<tr>
<td>Changing habits and routines e.g., removing appliances from standby or switching them off</td>
<td>Environmental engagements e.g., joining local campaigns or local community-based projects</td>
</tr>
</tbody>
</table>

References


