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Geographies of regulatory disparity underlying Australia's energy transition

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Disparities in electricity retail regulatory protections will see some consumers approaching energy transition from an uneven footing. Here we examine the spatial organization of regulatory inequities in Australia by mapping electricity legal protections for settlements nationwide. Multiple logistic regression (n = 2,996) identifies the geographic and socio-demographic characteristics of settlements likely to be underserved by regulations to: protect life-support customers, guarantee service levels, clarify connection requirements for rooftop solar, require disconnection reporting and set clear and independent complaints processes. Assessing whether communities receive fewer than four of five protections, we find that Indigenous communities are 15% more likely to be underserved across multiple metrics and remote communities are 18% more likely to be underserved. These groups overlap. Those communities whose lands are rich in resources necessary for energy transition are simultaneously at risk of non-recognition of their own energy needs under current regulation, requiring policy remedies for a just transition.

Internationally there is a movement to achieve a just transition to renewable energy sources, where just transition encompasses broad elements of energy justice beyond employment outcomes[1,2]. Calls for a just transition necessarily recognize that new energy systems will be built on and potentially reproduce the winners and losers of existing energy systems[3]. Within current energy systems, groups at the spatial periphery are at high risk of having their energy needs under-recognized and procedurally neglected[4,5]. Many communities hosting new renewable energy developments, particularly Indigenous communities, face procedural injustices in the form of limited access to decision-making procedures for developments on their lands[6–8]. There is a need to better understand the spatial and socio-demographic characteristics of communities facing non-recognition in protections afforded by present day electricity retail regulations, wherein non-recognition refers to the needs of certain groups being neglected or ignored[4].

Australia, home to one of the oldest continuing cultures in the world, is expected to play a key role in energy transition globally[9], yet the geographies of disparity in the present day regulations governing consumer electricity retail are largely invisible. Australia is assumed to have achieved the goal of universal access to energy for all, with an electricity rate of 100% (ref. 10), but this presumed ubiquity belies persistent disparity in who experiences energy insecurity and where they reside[11–19]. Aboriginal and Torres Strait Islander (prepay) customers in Australia's remote Northern Territory (NT) are more likely to experience 'self-disconnection' during temperature extremes, which climate change only makes more frequent[19]. As seen during the COVID-19 pandemic and recent cost-of-living crises, regulatory difference shapes access to financial support for essential home energy services such as refrigeration and space cooling[20–22].

Electricity use in modern societies is critical for many aspects of well-being[23–26], and differences in regulatory protections can have substantial social impacts including by reinforcing marginalization of historically oppressed or colonized communities[27]. Literature mapping spatial differences in existing energy protections has begun to

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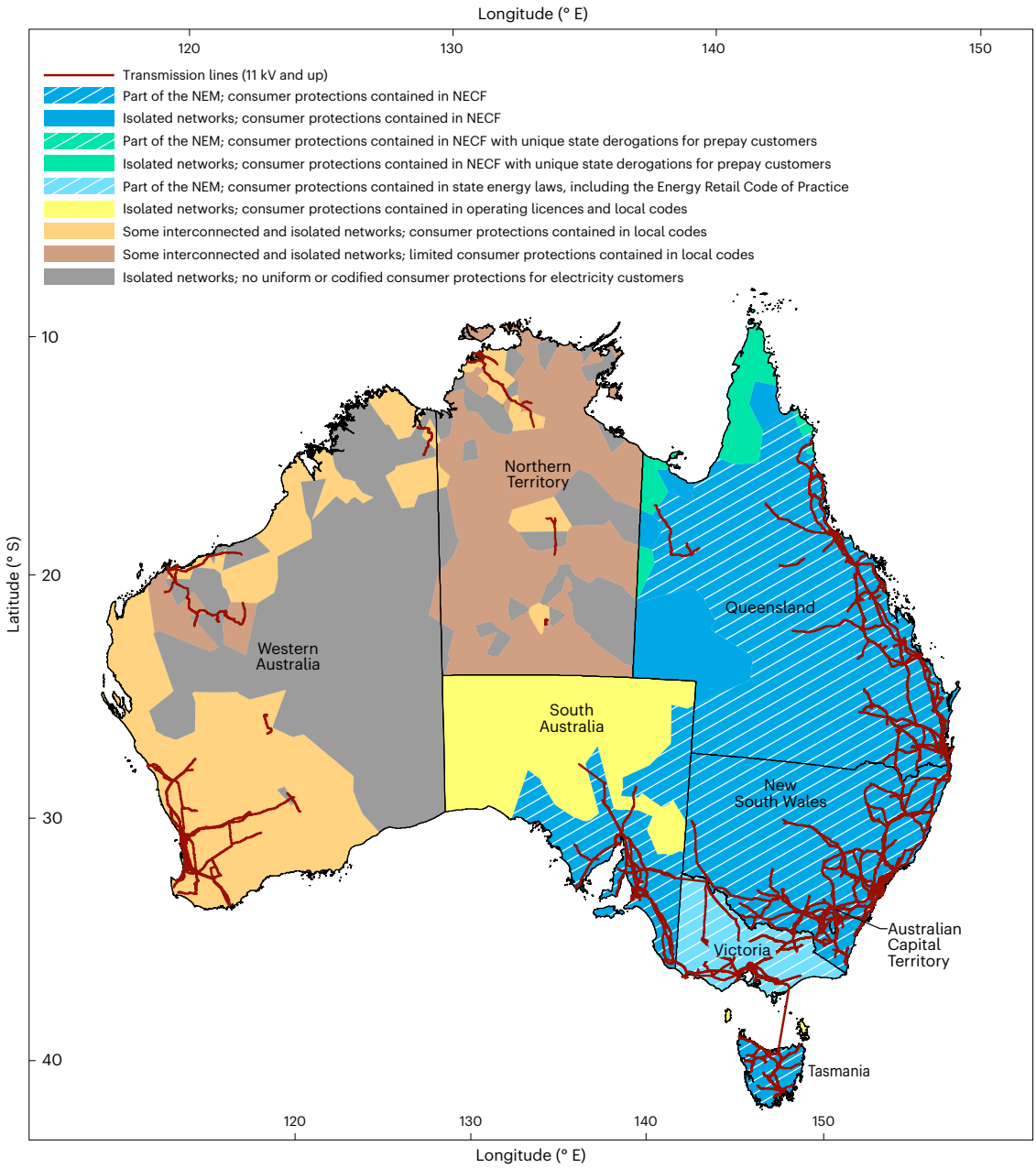

Fig. 1 | Overview of electricity retail regulatory environment and transmission infrastructure by location in Australia as of July 2022. Detail pertaining to variation in legal protections described in Figs. 2–5. Regulatory environment details are extracted from our data collection. Electricity transmission lines shown on map are from Geoscience Australia under a Creative Commons license CC BY 4.0.

demonstrate the extent of these disparities, including mapping differences in disconnection protections in both the United States and European Union[28–30]. Yet, nationwide mapping of regulations across more granular geographies remains underexplored. Interview-based work has identified that peripheral locations in Wales face challenges accessing energy services[31] and that electricity governance arrangements in Rio de Janeiro are negotiated and permitted to vary based in part on perceived commercial risk within different parts of the city[32]. Existing geospatial studies regularly focus on single metrics[28], with an emerging focus on intersectionality related to: material precarities[33], energy and transport insecurity[34], internet and energy insecurity[35] and remedial policy during times of crisis[36–38].

Our study identifies settlements with fewer extant legal protections for electricity services, mapping those at risk of further exclusion from the benefits of energy transition. We find that life support protections, guaranteed service levels and disconnection reporting that are ubiquitous for residential customers within urban and regional areas are often absent in remote settlements. Remote settlements and settlements with majority Indigenous population are respectively 18% and 15% more likely to lack comprehensive regulatory and legal protections compared with non-remote and non-Indigenous settlements. These findings show that some communities face energy transition from an uneven footing in Australia and that action is needed to support a just transition to avoid reproducing or exacerbating non-recognition in future energy systems.

Australian electricity retail regulation context

Australia is a large country (7.7 million km^2 compared with the 8 million km^2 of the contiguous United States), with grid infrastructure concentrated on the east coast and not connected across the whole

country (Fig. 1). Smaller remote settlements rely on standalone distributed electricity networks. In Australia, states and territories (not the Commonwealth) have legal jurisdiction over electricity. All states and mainland territories (with the exception of Western Australia (WA) and the NT) have opted to enact coordinating legislation, forming what is known as the National Electricity Market (NEM). The NEM began operating in 1998 through the National Electricity Law (NEL), which governs market operations in the NEM. The National Energy Customer Framework (NECF) including the National Energy Retail Law (NERL) and National Energy Retail Rules is likewise uniform legislation in relation to the retail and distribution of electricity and gas to customers connected to the NEM. It provides largely similar protections[39] to consumers within those interconnected regions (excepting Victoria and regulatory exceptions; Fig. 1 and Supplementary Note 1). Evolution of electricity retail regulation in WA and the NT, alongside regulatory exceptions and the existence of small and isolated networks within NEM states (for example, in South Australia (SA); Supplementary Note 2), has given rise to different electricity retail regulations across the country (Fig. 1). Not all settlements are covered by legislative protections for electricity, most notably in the NT and WA (Fig. 1 and Supplementary Note 3).

The NERL recognizes the principles that the supply of energy is an essential service for residential customers and that disconnection of premises of a hardship customer due to inability to pay energy bills should be a last-resort option, but Australia does not ban disconnections for non-payment except for (most) life-support customers and (some) moratoria during the COVID-19 pandemic[38]. Some international regulatory environments recognize the essential nature of electricity more strongly (Supplementary Note 4). Permissible payment types in Australia vary by jurisdiction: prepayment metering, where customers pay for electricity before using it and are disconnected if the meter runs out of 'credit', is allowed in some parts of the country, yet is prohibited in Australia's most populous states (Supplementary Table 1). Internationally, prepay consumer protections commonly differ from those available to post-pay customers[40]. Prepay is not a traditional customer–utility relationship (advance payment contractually resembling exchange of goods rather than an essential service). It is lightly regulated in most countries and has generated controversies associated with customer well-being[41].

Australian settlements underserved by electricity regulation

We reviewed each of the 284 documents recording legal protections pertaining to 3,047 settlements across Australia as of 1 July 2022, including those small settlements with fewer than 200 people. Of these 3,047 settlements, the 51 settlements missing data on relative socio-economic advantage are included in mapping but not the subsequent statistical analyses. Our review indicates that an estimated 5 million Australians (approximately 20% of the population) are living in settlements where not all customers are guaranteed protections across the five dimensions of life support, rooftop solar connection, disconnection reporting, guaranteed service levels and clear and independent complaints processes (Fig. 2 and Supplementary Table 2). Figure 2 summarizes the findings of legal protections reviewed across these five indicators and illustrates the compounding disparities; a settlement was considered to lack protections if not all customers (both prepay and post-pay) were guaranteed that protection.

We use multiple logistic regression to examine whether remote communities and Indigenous communities are statistically more likely to be underserved by electricity regulations. Five dependent variables associated with legislative protections are examined: (1) life-support protections, (2) guaranteed service levels, (3) clear solar connection processes, (4) disconnection reporting requirements and (5) complaints process clarity and independence. To give context to our regulatory review, we spoke to community and regulatory organizations whose remit includes electricity access (12 organizations, 32 individuals) who recommended creation of a sixth indicator, 'underserved on multiple metrics', indicating that a settlement received fewer than four of five protections (that is, is not a blue cross in Fig. 2; comprising a population of approximately 290,000 residents). Analyses control for the settlement population and the Index of Relative Socio-economic Advantage and Disadvantage (IRSAD).

Remote settlements and Indigenous settlements are more likely to be underserved on multiple metrics (model 6). Remote settlements are 18% more likely (vs urban and regional) to be underserved on multiple metrics, and Indigenous settlements are 15% more likely (vs not majority Indigenous) to be underserved on multiple metrics (margins contrast, $p = 0.000$ for both). Remote settlements and Indigenous settlements are less likely to have solar connection clarity and less likely to have clear and independent complaints processes (models 3 and 5). Remote settlements are 38% less likely (vs urban and regional) to have solar connection clarity and 14% less likely to have clear complaints processes (margins contrast, $p = 0.000$ for both). Indigenous settlements are 48% less likely to have solar connection clarity and 10% less likely to have complaints process clarity, compared with settlements that are not majority Indigenous (margins contrast, $p = 0.000$ for both).

For three of our dependent variables, we find that being in a non-remote settlement perfectly predicts success (models 1, 2 and 4). That is, all settlements that are urban or regional have legally enforceable protections for all customers regarding life support, guaranteed service levels and disconnection reporting. For these indicators, we examine variation only within remote settlements ($n = 610$). Those remote settlements where over 80% of the population is Indigenous are less likely to have life-support protections, guaranteed service levels and disconnection reporting requirements for all customers (models 1, 2 and 4). Compared with remote settlements that are not Indigenous, Indigenous settlements are 61% less likely to have life support protections, 46% less likely to have guaranteed service levels and 63% less likely to have disconnection reporting requirements (margins contrast, $p = 0.000$ for all).

Higher IRSAD scores (indicating a relative lack of disadvantage and greater advantage in general) are correlated with higher likelihood of having life-support protections, guaranteed service levels, disconnection reporting requirements and clear complaints processes. Higher IRSAD scores are likewise correlated with lower likelihood of being underserved overall. Higher population is not associated with any differences in legal protections.

The models in Table 1 interpret settlements as having life-support protections in cases where life-support registration and prepay use are mutually exclusive (Fig. 3a and associated text provide additional detail). However, in practice, prepayment customers in remote areas may still face practical challenges associated with registering for life support and associated payment plan changes. We include an additional analysis in Supplementary Table 3 that treats life support and prepayment incompatibility as being consistent with an absence of protection. As with our main analyses in Table 1, Indigenous and remote settlements are less likely to have life-support protections and more likely to lack protections across multiple dimensions.

Settlements with fewer protections for electricity access

Life-support customers are by definition those who face increased risks of morbidity and mortality when disconnected from electricity. Definitions of life support vary by jurisdiction but uniformly describe life-support requirements in terms of reliance on particular equipment (Supplementary Table 4). For 161 remote settlements where there are no consumer-focused regulatory frameworks, life-support protections are unavailable for both payment types, with potentially severe implications for residents (Fig. 3a). In 412 settlements prepayment is incompatible with life support. Three scenarios were identified where life-support customers could use prepayment (Supplementary Table 5

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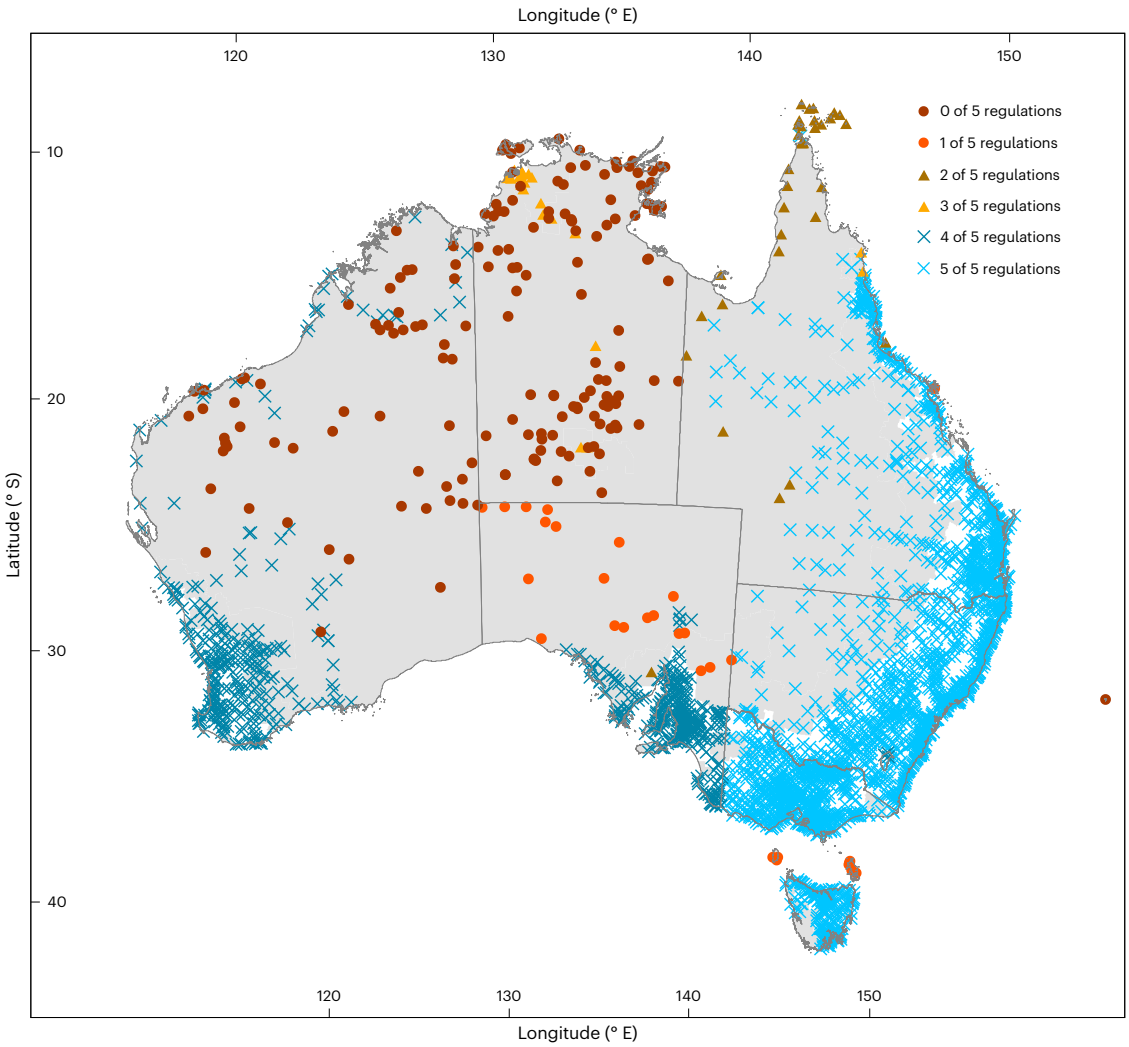

Fig. 2 | Absence of legal protections across multiple dimensions. Considering whether a settlement is underserved across multiple dimensions, compiling (1) life-support protections, (2) guaranteed service level, (3) solar connection process stated in contract, (4) disconnection reporting requirements and (5) complaints process clarity and independence (n = 3,047 settlements). Remote areas shown in grey.

and notes), but only one of these scenarios (for 8 SA settlements) provides legal protections from disconnection. Mutual incompatibility of prepayment and life support may not provide consumer protection: during consultations, one community organization described that consumers could face practical difficulties in switching payment type. Document review indicates that responsibility to register for life support and navigate various procedures is allocated to the individual level, with a potentially prohibitive paperwork burden to access protections.

As of July 2022, only the state of Victoria provides protections from disconnection for those experiencing family violence (Fig. 3b and Supplementary Table 6). 'Family violence' is expansively defined in many Australian jurisdictions to include all aspects of behaviour that seek to threaten, coerce, abuse or control a family member such that that person feels fear for theirs, or another family member's, safety or well-being. As an essential service, electricity access can be exploited as a form of control[42]. Aboriginal and Torres Strait Islander women often face severe and discriminatory systemic barriers to addressing family violence[43]. There is a pervasive fear of child removal, linked with the colonial policy history of enforced Indigenous child removals (Stolen Generation) and with disproportionately high rates of Aboriginal children currently in out-of-home care[43]. Protections that took effect in Victoria from 1 January 2020 require electricity retailers to have a family violence policy and outline minimum standards of assistance for these vulnerable customers, including the acknowledgement of family violence as a potential cause of payment difficulty.

In Australia, very few settlements receive any protections from disconnection upon non-payment during very hot or very cold temperatures (Fig. 3c and Supplementary Table 7). Disconnection from electricity during very hot or very cold temperatures can have impacts on mortality rates; when services are disrupted, exposure to temperature extremes can amplify risks associated with underlying health issues with profound adverse outcomes[19,28,44–46]. Some member states within the European Union and United States provide exemptions from disconnection during extreme temperatures, with threshold cut-offs varying by jurisdiction[28,47,48]. Although the NECF in Australia creates a framework to secure protections from disconnection during extreme weather, only SA has implemented the state-level regulations necessary to activate these protections, and as of July 2022 this only protected on-grid customers who post-pay.

Many remote settlements do not have guaranteed service levels (Fig. 3d and Supplementary Table 8). guaranteed service levels seek to compensate eligible customers for unplanned supply interruptions. Community organizations reported slow utility service response times following damage to electricity infrastructure in remote locations, which could compound the coercive potential of electricity supply disruption. The types of interruption covered by guaranteed

Table 1 | Multiple logistic regression examining likelihood of remote and Indigenous settlements having protections across five indicators and likelihood of being underserved by protections in multiple dimensions

	(1)	(2)	(3)	(4)	(5)	(6)
	Has life-support protections	Has guaranteed service level	Has solar connection clarity	Has disconnection reporting requirements	Has complaints process clarity and independence	Is underserved on multiple metrics
Remote	(all remote)	(all remote)	−1.82*** (0.11) [0.000]	(all remote)	−4.11*** (0.47) [0.000]	4.53*** (0.47) [0.000]
Over 80% Indigenous	−3.25*** (0.36) [0.000]	−2.45*** (0.33) [0.000]	−2.31*** (0.30) [0.000]	−3.23*** (0.36) [0.000]	−2.31*** (0.32) [0.000]	2.98*** (0.34) [0.000]
Population (1,000s)	0.01 (0.09) [0.883]	−0.09 (0.13) [0.459]	−0.00 (0.00) [0.815]	0.02 (0.08) [0.803]	−0.00 (0.00) [0.664]	0.00 (0.00) [0.649]
IRSAD	0.42** (0.15) [0.005]	0.43*** (0.13) [0.001]	−0.00 (0.07) [0.949]	0.48** (0.15) [0.002]	0.41** (0.13) [0.001]	−0.39** (0.14) [0.004]
Pseudo R^2	0.48	0.36	0.19	0.48	0.59	0.66
n	610	610	2,996	610	2,996	2,996

Standard errors in parentheses. $^{+}p<0.10$, $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$. Precise two-tailed *p* values in square brackets. Adjustments were not made for multiple comparisons.

service levels commonly do not include supply interruptions caused by third-party interference.

Retailer definitions of hardship universally exclude prepayment customers (Supplementary Table 9), as hardship is defined in relation to either a consumers' inability to pay bills (which prepay customers do not receive) or to a specified level of accrued debt (which for prepay is limited to small amounts of friendly credit). This exclusion by definition of prepay customers from hardship reporting and supports puts these customers at a disadvantage relative to other payment types and increases risk of non-recognition.

Settlements with constraints to installing rooftop solar

Internationally households wanting to install solar often face barriers to navigating the process for grid connection[49–51]. Stakeholder engagements and prior Australian research[52] identify these connection processes as an impediment facing remote and Indigenous communities attempting to take part in energy transition. In Australia, distributors own the poles and wires and are responsible for the connection process. Although some states and territories have overarching legal requirements for distributors to connect residential solar, these documents leave distributors with a high-to-moderate degree of discretion in permitting individual residential connections to networks (Fig. 4a and Supplementary Table 10). In full discretion cases, there is no relevant regulation that specifies conditions under which distributed solar should be connected; in moderate discretion cases, a distributor is required to have a 'model standing offer' or equivalent that establishes the conditions under which solar would be connected. Many smaller remote settlements are subject to network constraints and newly offered capacity allocations are oversubscribed in short order. Some progress is being made in this regard, for example, in WA where the distributed network service provider Horizon Power has committed to a policy of no solar refusals by 2025[53].

Because distributors always retain some discretion, to understand customer ability to enforce a right to connect solar, we review standard contracts that customers would navigate in the process of connecting residential solar to a distributor network (such as model standing offers; Fig. 4b and Supplementary Table 11). The conditions under which prepay customer applications to connect would be approved are only clear in the contracts for two settlements. This accords with recent research showing prepay customers are either precluded or face greater barriers when seeking to install rooftop solar[52]. When distributor standard contracts do not set out the conditions under which consumers could reasonably expect their residential solar connection to be approved, this presents a barrier to solar installation[49–51]. Settlements within the NEM and major networks of the NT have clear contractual processes for post-paying customers, but prepay customers may face challenges installing residential solar due to lack of clarity. Outside the NEM, both prepay and post-pay consumers have limited recourse to pursue residential solar grid connection in the event of a distributor refusal—due to the lack of a legal basis to connect, lack of standard contracts with clear parameters for connection or a combination of both.

Settlements that face weaker reporting requirements

Substantial geographic variation is evident in disconnection reporting requirements (Fig. 5a and Supplementary Table 12). Although disconnection reporting in itself does not offer a protection, the lack of reporting precludes efforts to secure improved protections for groups facing high disconnection rates, raising the risk of non- or mis-recognition. The lack of consistent disconnection reporting for prepayment customers in Queensland (Supplementary Note 5), NT, WA and SA obscures the true level of energy insecurity in these regions[26,54].

Complaints processes are an essential procedure for correcting unique errors (via the utility) and systemic inequities (via independent processes)[7,55]. Clarity and independence of process ensure consumers may seek redress in the case of failure to provide protections that are otherwise legally required. Numerous remote communities in the NT, WA and SA lack these complaints process protections, while they are provided to Queensland card-operated communities (Fig. 5b, Supplementary Table 13 and Supplementary Note 5). Those remote communities that do lack clear and independent complaints processes are the same communities that lack other regulatory protections across the categories examined. These communities, particularly Indigenous communities, face challenges in seeking remedy through complaints processes, such as lack of materials in their own languages and limited access to internet[18,56]. Procedural injustices occur when certain groups have systematically lesser access to the procedures of institutional governance and decision-making processes that are relevant to their needs, resulting in marginalization and discriminatory outcomes[55,57,58].

Discussion

In investigating the socio-spatial diversity of electricity retail regulation across 2,996 Australian settlements nationwide, our findings reflect a confounding albeit commonplace reality: remote communities in Australia are less likely to have comprehensive regulatory protections for access to electricity and the services it provides. In a disconcerting measure of indifference, remote settlements are 18% more likely to be underserved across multiple metrics. Analyses further highlight the possibility that Indigenous peoples, whose lands are among the most

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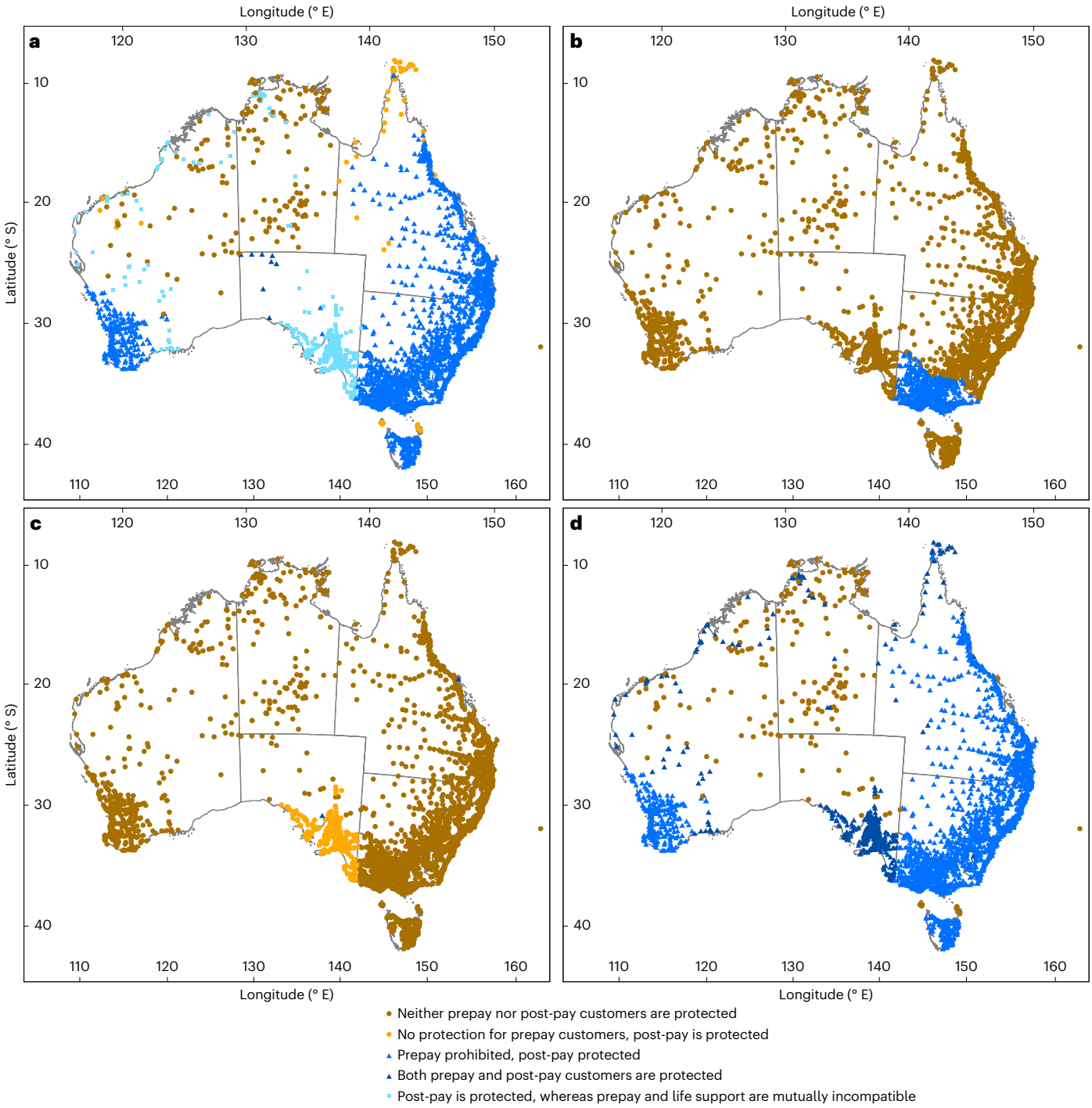

Fig. 3 | Mapping legal protections related to disconnection and service levels. a–c, Mapping legal protections that establish additional protections from disconnection for life-support customers (**a**), those experiencing family violence (**b**) and during extremely hot or cold temperatures (**c**). **d**, Mapping where guaranteed service levels apply (n = 3,047 settlements).

important contributors to the transition to renewable energy[3,59], are likely to be underserved by regulations that would secure their own energy needs. Our analyses find that settlements with over 80% Indigenous share of population are 15% more likely to be underserved across multiple metrics compared with their non-Indigenous neighbours. Regulatory review indicates that an estimated 5 million Australians (approximately one in five) are living in settlements where not all customers are guaranteed protections for life support, disconnection reporting, solar connection clarity, guaranteed service levels and independent complaints processes.

These findings contribute to the international debate on just transition and energy justice, and the concern that transitioning energy systems will perpetuate existing winners and losers[3]. The concept of just transition brings together aligned notions of environmental justice, climate justice and energy justice to reflect an overarching societal goal that leaves no-one behind in the process of systemic change required to respond to the climate crisis[1,2]. Though electricity regulations have long been viewed as technical, in practice they are a social policy that can have far-reaching impacts[27]. We find that many remote communities and Indigenous communities are entering energy transition from

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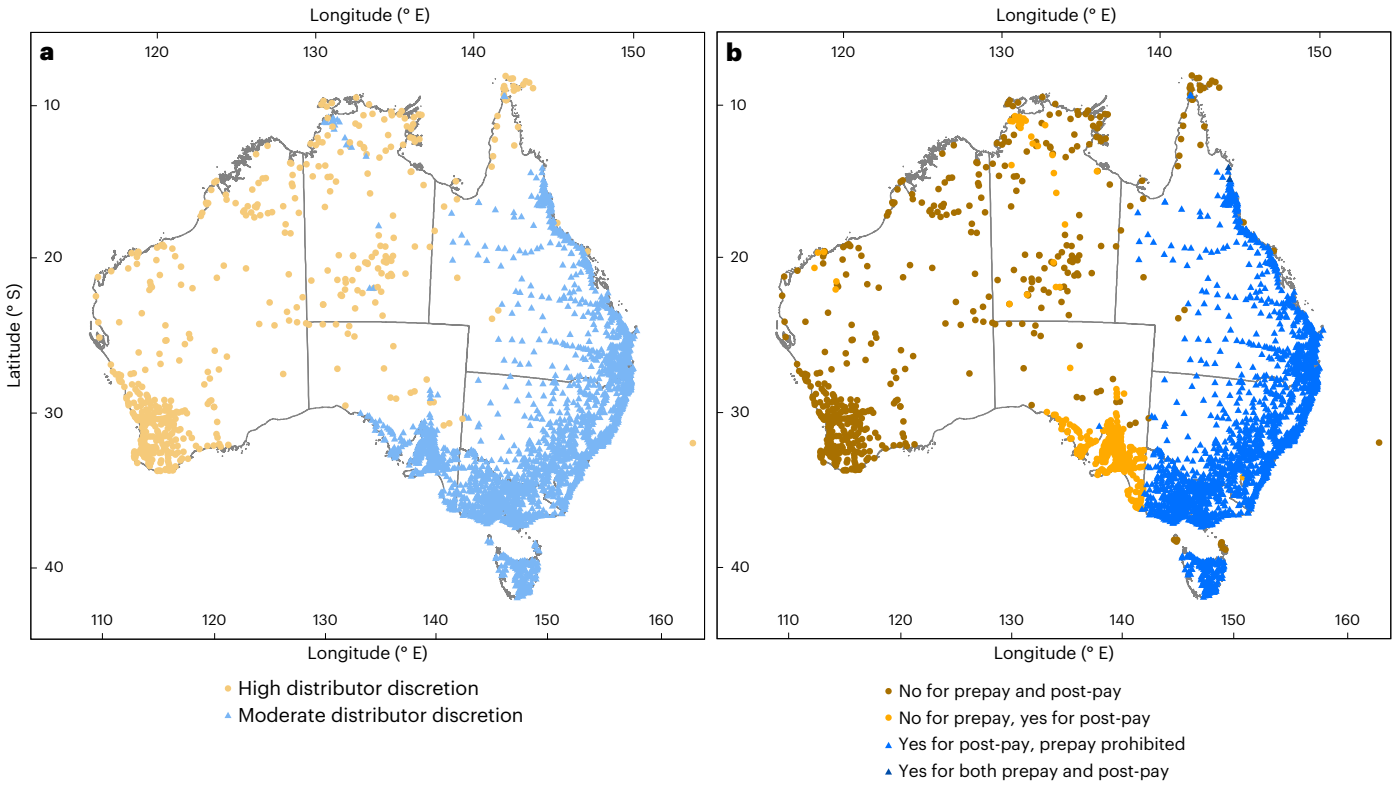

Fig. 4 | Mapping legal protections related to rooftop solar connection. a,**b**, Mapping ability to connect residential solar established by act or regulation (level of distributor discretion) (**a**) and whether the contract with the distributor lays out clear conditions under which the consumer could reasonably expect to have a connection request for solar approved (**b**) (n = 3,047 settlements).

an uneven footing, lacking commensurate ability to install their own rooftop solar, lacking ubiquitous disconnection reporting that makes energy insecurity visible, lacking procedures to redress poor service levels and in some cases even lacking clear protections for life-support customers. This may lead to entrenched injustices during energy transition[60]. These communities currently underserved by electricity regulations are experiencing multiple dimensions of energy injustice and as such are not being engaged in a just transition[1,2].

Indigenous lands hold many of the minerals critical for energy transition[59] and host rich renewable energy resources[61], yet many of these communities are currently underserved by electricity systems, face challenges installing solar[52] and face frequent disconnections[19]. In Australia, lands critical to the nation's aspirations for becoming a green energy superpower[9] are among the worst served by today's electricity retail regulations. This echoes the growing international literature on non-recognition of consumer needs in energy peripheries[4,5,31]. Distributed energy resources have the potential to democratize control of energy systems and restore decision-making power to communities[27], yet our mapping shows that remote communities are underserved both by protections for centralized energy systems and by processes that would support household installation of distributed renewable energy.

Our findings reflect that communities at the periphery geographically and politically often face unique challenges of energy vulnerability[4,5,31]. Peripheral places often hold less economic, social and political power[5] and may be more likely to have their needs go unrecognized or even ignored[4]. Remote communities in Australia are so designated due to distances that people have to travel to receive basic services[62], and although remote places are in no way uniformly disadvantaged, many of Australia's most socio-economically disadvantaged communities are in remote locations[63]. The division of jurisdictional accountabilities between the Commonwealth and the states and territories for the funding of essential services in Aboriginal and Torres Strait Islander communities represents a piecemeal approach[19] by settler policymakers that has too often resulted in services that do not adequately reflect the needs of communities themselves. There is an urgent need for regulatory frameworks to be developed that better support the rights of Australia's First Peoples to participate in decision-making about present and future energy systems.

Many underserved communities are on lands that will experience substantial temperature increases as a result of climate change[64,65], requiring an ever greater reliance on electricity for cooling to maintain thermal safety and comfort[66–68]. The lack of regulatory protections in remote communities intersects with a wide array of energy justice applications, including energy poverty (welfare), climate change (fairness and responsibility), energy resources (prosperity) and energy and due process (procedural justice)[55]. Current Australian protections from disconnection during extreme weather lag those protections granted in many parts of the United States and the European Union[28,47], with most Australian jurisdictions lacking codified protections from disconnection during extreme heat or cold weather events. There is a need to improve protections for all Australians, but in doing so there is a need to ensure that protections do not reproduce existing spatial patterns of underserving remote and Indigenous communities; these communities are likely to experience increased extremes in a changing climate[64,65].

Having mapped the national scale of regulatory difference for electricity retail protections, the next analytical step will be to determine the impacts of these disparities on outcomes for human communities, such as health and well-being. The absence of disconnection reporting for prepay customers has wide-reaching consequences. Australia's Closing the Gap agreement is intended to improve life outcomes for Aboriginal and Torres Strait Islander people[69]. Yet, the Commonwealth agency charged with monitoring progress on this area has been unable to report against essential services (electricity) progress due to lack of data[70]. Reporting of self-disconnections should be mandatory in

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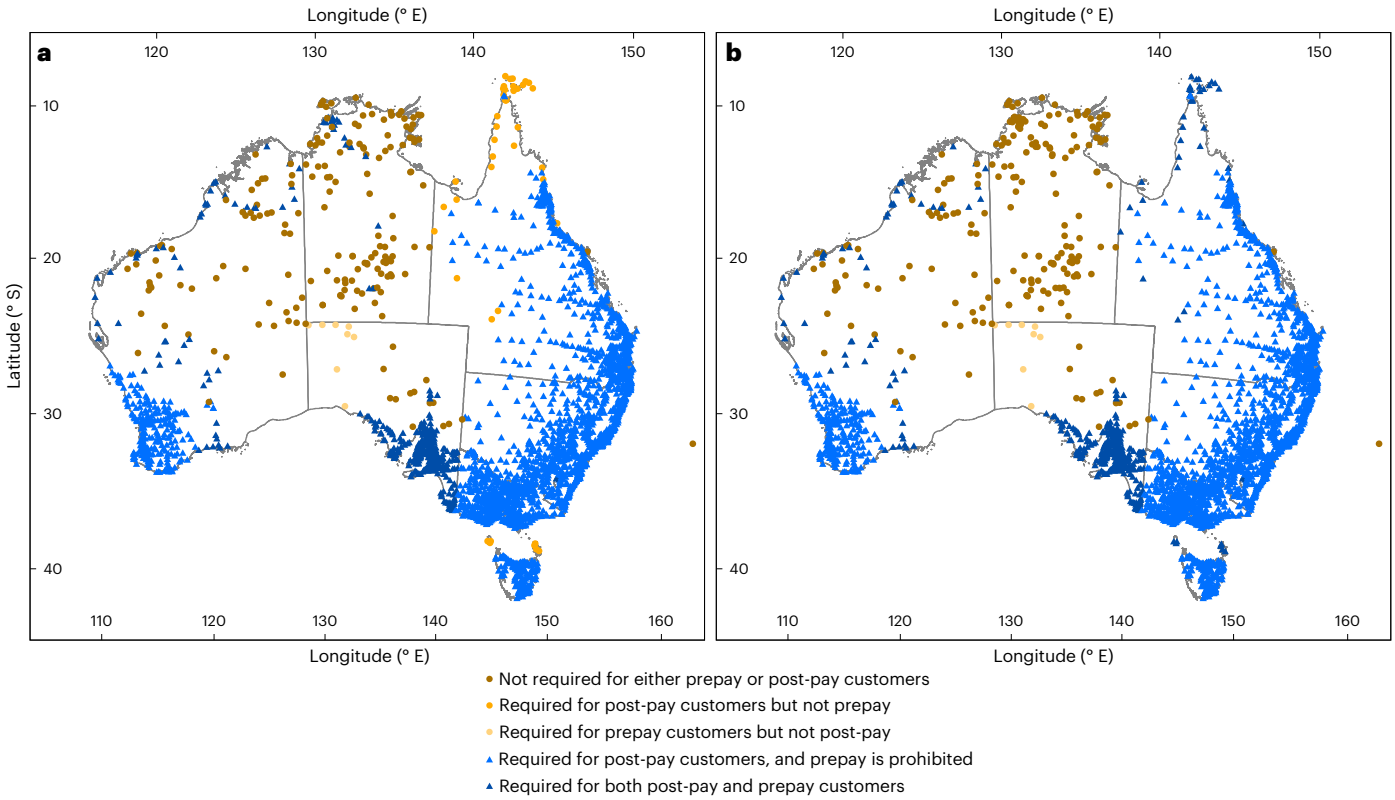

Fig. 5 | Mapping legal requirements for reporting and complaints processes. a,**b**, Mapping legal requirements to report disconnections (**a**) and have clear and independent complaints processes (**b**) (n = 3,047 settlements).

all jurisdictions. Further, we recommend that Australian regulatory bodies require the number of registered life-support customers by payment type in each jurisdiction to be publicly reported; reporting could highlight areas of under-registration, such as in areas where prepay and life-support protections are mutually exclusive. Australia's regulatory agencies charged with governing electricity retail protections could take this role. Future work could consider the Australian governance structures that gave rise to the disparities in regulatory protections, including use of prepayment, that we see clearly visualized in our mapping.

In mapping the spatial arrangement of regulatory disparity, it is essential to acknowledge the legacy of cartography as an instrument of governmentality in delineating those territories stolen from Australia's First Peoples, whose lands they never surrendered. Even the most well-intentioned map-making risks obscuring or misrepresenting procedural, distributive and recognition injustices for specific communities and/or individuals. Moreover, regulation undergoes frequent iteration, and there were numerous changes proposed, in draft form or in the process of introduction during this review. We seek to dispel here any perception of a deficit narrative of Australian rurality and acknowledge the efforts of the many individuals, communities, advocates, utilities and policymakers engaged in finding local solutions and alternatives to the challenges identified here. Methodologically, we recognize that identifying underserved communities with a simple count of regulations provided does not capture the potential for regulations to have differing extents and magnitudes of impact. We opted for a simple count as the most transparent indicator of locations facing disadvantage in multiple areas, while mindful that this may not fully capture regulation in each practical application. Finally, we note that the situation in Australia is unique to this country, its history, demography and geography. Nonetheless, we hope that by identifying patterns of underserved locations and demographics shown in this work, we create the impetus for future work interrogating local situations globally, so as to identify disparities in current electricity regulations that may reproduce inequalities in transitioning systems.

Methods

Ethics and inclusion statement

Our research methodology is informed by the principles underpinning ethical Australian Indigenous research outlined in the Australian Institute of Aboriginal and Torres Strait Islander Studies Code of Ethics for Aboriginal and Torres Strait Islander Research[71], and our research team is committed to the principles of Indigenous self-determination, Indigenous leadership, impact and value, sustainability and accountability. V.N.D. is senior Aboriginal researcher at Tangentyere Research Hub in Mparntwe (Alice Springs) and a visiting Indigenous fellow at the Australian National University (ANU) Centre for Aboriginal Economic Policy Research. M.K. is senior policy manager at Tangentyere Research Hub and a visiting fellow at the ANU's Centre for Aboriginal Economic Policy Research.

This research both springs from and builds upon efforts by our collaborators at the Tangentyere Research Hub, starting in 2019. Research approach and methods were determined in collaboration with these local partners. Roles and responsibilities were agreed among collaborators early in the research, having developed out of our previous collaborations on a related topic[19] and included plans to centre the perspectives of Indigenous researchers. Capacity building included exchanges between researchers in Central Australia and the NT, such as time spent by B.R. in Alice Springs and time spent by V.N.D and M.K. in Canberra. Local capacity constraints may have circumscribed how comprehensive the analysis could be; however, in no other ways would this research have been prohibited.

This research occurs within Australia, and it was conducted with ethics approval from the ANU's Research Ethics Committee approval 2022/443. Despite the desktop, statistical, nature of the research, it was

conducted in accordance with the National Health and Medical Research Council's National Statement on Ethical Conduct in Human Research.

Geography identification

The Australian Bureau of Statistics (ABS) Urban Centres and Localities (UCL) dataset identifies all settlements in Australia with populations of 200 or more people. To capture all possible settlements, including small remote locations, we developed a custom settlement classification based on the ABS smallest geographical units, Mesh Blocks (MBs), which cover the whole country and generally contain 30 to 60 dwellings. This process identified a total of 3,089 settlements across all of Australia, compared with the 1,809 settlements captured in the 2021 UCL dataset. We identified settlements using several steps:

(1) Estimated residential populations (ERPs) at 30 June 2021 are imputed for every MB for the total population and the Indigenous population by progressively downscaling state/territory ERPs using Census counts tabulated at the SA4, SA3, SA2, SA1 and MB level.
(2) All MBs within a UCL are allocated to that UCL.
(3) All remaining MBs classified by the ABS as being primarily used for residential purposes are grouped into clusters based on spatial contiguity.
(4) Clusters of MBs that are contiguous with a UCL are allocated to that UCL.
(5) Unallocated MB clusters are classified based on OpenStreetMap data. Specifically, a place name is allocated to a cluster of MBs if the MBs intersect an OpenStreetMap node with a 'place' tag containing any of the values 'city', 'town', 'village', 'hamlet' or 'isolated_dwelling' and with a 'name' tag.
(6) Unallocated MB clusters with a total ERP of 20 or less are excluded.
(7) Unallocated MB clusters that are within 10 km of a UCL are allocated to that UCL.
(8) Unallocated MB clusters that are within 10 km of a named OpenStreetMap place node (as above) are allocated to that place.
(9) Outliers (for example, prisons, a fracking field) were manually removed.
(10) Manual checking against satellite imagery and gazetteers was undertaken, especially of those MBs allocated to a settlement on the basis of distance to the closest named place. Numerous place nodes were added manually in OpenStreetMap based on a visual inspection of interim results.

This method treats Indigenous communities and small non-Indigenous settlements identically. We caution that this method does not capture all populated small settlements, such as remote Indigenous homelands that are seasonally populated living areas on Traditional Lands. Some smaller communities are not identified under our geographic methods as discrete settlements, instead being merged with larger nearby settlements. This means that some small settlements do not appear by name, despite having distinct regulatory regimes identifiable in other documentation. For example, Acacia Larrakia and Kybrook Farm in the NT are not discretely identified, despite having a distinct set of regulation. We note these agglomerated settlements as being a limitation of our method. Given these limitations, our analyses probably under-represent the extent to which smaller communities are underserved by current regulation.

Remoteness and socio-demographic variables

For each identified settlement, we calculated the latitude and longitude of its centroid. The ABS remoteness classifications were then added via spatial join of Remoteness Area 2021 ABS shapefile to geographic centre point of each settlement. These classifications are Major Cities, Inner Regional, Outer Regional, Remote and Very Remote. We identified that in rare cases, the shape of a settlement caused the centre point to fall into a neighbouring remoteness category. Therefore, we cross-checked all settlements within 1 km of the nearest remoteness boundary against their remoteness category in the ABS' ArcGIS Online Map Viewer with the 2021 remoteness boundaries as a layer.

We calculated socio-demographic variables for each settlement based on SA1-level Socio-Economic Indexes for Areas (SEIFA) indicators from ABS 2021: IRSAD, Index of Relative Socio-economic Disadvantage, Index of Economic Resources and Index of Education and Occupation. Each MB was assigned the SEIFA score of its enclosing SA1. Settlement-wide SEIFA scores were then calculated as a population-weighted average of its constituent MBs. Statistical analyses use IRSAD as a control variable. This ABS indicator summarizes information about the economic and social conditions of people and households within an area, including both relative advantage and disadvantage indicators. This is used in place of individual indicators such as income, employment and housing tenure due to the likelihood that those variables are highly collinear.

Remoteness is coded dichotomously such as that Remote or Very Remote settlements are coded 1 whereas Major Cities, Inner Regional and Outer Regional are coded 0. Indigenous share of the population is coded as a dichotomous variable where 1 denotes a settlement where over 80% of the population is Indigenous, and 0 denotes otherwise. This threshold was chosen to capture discrete Indigenous communities, that is, those predominantly Indigenous communities that are established on Aboriginal land and have historically had housing or infrastructure that is managed on a community basis. Pre-coarsening, each settlement's total ERP, Indigenous ERP and percentage of a settlement that identify as Indigenous were calculated by summing the ERPs associated with each MB that comprise the settlement (step 1 in geography identification). These settlements formed the basis of our subsequent regulatory coding and analysis and were manually matched by settlement name.

National review of retail legal protections

Data were collected during October 2021 to February 2023 and included review of 1,159 regulatory documents (284 of which are legal documents used for protection coding). Our review focused on consumer-facing electricity retail regulation (such as the NERL) as opposed to energy regulation more broadly (such as the NEL). Where categories of interest for electricity services fell within distributor remit (that is, solar connections), we reviewed the appropriate documents associated with electricity regulation (such as the National Electricity Rules made under the NEL). We mapped 12 categories, four of which were combined into a single indicator ('minimum complaints protections'). Data collection was completed during October 2021 to February 2023 and included review of 284 legal documents to identify protections in each settlement. Regulatory environment at the settlement level was cross-checked with review of over 800 further documents to ensure no exceptions were overlooked. Settlements were coded based on their legal protections up to and including 1 July 2022. Regulation undergoes frequent iteration, and there were numerous pending changes proposed in draft form or in the process of introduction during our review (notably in remote WA, though this is unlikely to change community status in the short term; Supplementary Note 6).

Legal protections were mapped for 3,047 of the geographically identified settlements. We excluded 42 settlements from mapping despite meeting geography criteria (Supplementary Table 14). Our review began by identifying those legal documents applicable to each settlement nationally following a two-step process, with some iteration. We first identified the acts, regulations, rules, determinations and orders governing electricity supply to residential customers in Australia, through top-down document identification of statutory frameworks governing the electricity industry in each state and territory—including legislation implementing the NERL and National Energy Retail Rules within Australia's NEM. We then reviewed core acts and associated regulations to identify which conditions or areas were exempted, excluded or not explicitly included in relevant coverages.

Second, we identified any licences, exemptions, codes and guidelines that form part of the regulatory frameworks; in many cases these documents identify settlements by name that subsequently facilitated coding at settlement level. If the regulatory context for a settlement could not be identified through these steps, document searches continued with expansion to other publicly available documents, including government and retailer/distributor websites and annual reports; however, these documents were used only to provide context on regulatory environment because they do not have legally enforceable status to provide consumer protections.

Statutory and contractual interpretation

The process of coding protections received in each settlement involved interpretation of legislation and contracts, where legal principles necessarily apply, thus we followed norms of legal interpretation in our document analysis and coding. In all cases, this involved the application of basic principles of statutory and contractual interpretation.

Legislative documents, such as the NERL, provide clear statutory protections and are legally enforceable, hence these documents formed the basis of our coding. Our coding questions (as specified in respective Supplementary Tables) generally followed the format of 'Are protections required by act, regulation, code or licence condition?', with all coded responses referring to specific provisions of legislative instruments (Data Availability statement to download the full dataset). For legislation, analysis proceeded by examination of 'the words, their context and the purpose of the legislation' without reliance on extrinsic materials[72]. In some cases, a relevant protection arose directly from one legislative provision; in other cases, it involved the combination of primary legislative provisions and associated subordinate legislation (for example, extreme weather protections present in the NERL but which are only enlivened by local subordinate legislation in SA).

Legislative instruments regarding consumer right to connect residential solar give discretion to distributors (Supplementary Table 10); hence we consulted distributor contracts that customers must navigate when installing solar to determine consumer rights (Supplementary Table 11). For contracts, analysis concerned the meaning of words in written contracts construed 'according to the strict, plain, common meaning of the words themselves'[73]. In some cases, external documents were referred to directly in the contract and were therefore 'read in' and naturally included in analysis, for example, utility hardship policies (Supplementary Table 4). When reviewing standard retailer contracts, we identified the exclusive retailer or retailer of last resort (the local area retailer obligated to provide households with an electricity contract where another retailer fails) and coded based on their regulatory context to represent a putative case. We did not consider 'market retail contracts' (under which retailers can offer special plans and bundles) when coding legal protections.

Alongside legal documents (such as legislation and customer contracts), our regulatory review included quasi-regulatory documents (such as utility policies and utility web pages). Quasi-regulatory documents were incorporated only where necessary to give context to legal documents, such as to identify arrangements in some off-grid settlements that lack legislative transparency, before proceeding to exclusion of that settlement (Supplementary Table 14) or where they were referred to in legal documents, such as life-support procedures or hardship policies. Quasi-regulatory documents were primarily used as a cross-check to ensure that no relevant legal documents had been overlooked in searching. Where further disambiguation was required, governing bodies were contacted directly for clarity (via email or telephone). A settlement was never coded as receiving protection only on the basis of a quasi-regulatory document, but in some cases these documents corroborated a lack of definitive protections conferred by legal documents. In cases where a quasi-regulatory document suggested a protection that could not be clearly confirmed in a legal document, that settlement was coded as lacking protections.

Engagement with community and regulatory organizations

Indicators were developed iteratively during three rounds of engagement and consultations with 32 intermediaries from energy, housing, health and social service organizations operating at national and sub-national levels representing a diversity of constituents and locations. We engaged with 12 organizations one to three times over the course of the project in semi-structured 1-h long discussions. Stakeholders included: the Northern Territory Council of Social Service, the South Australian Council of Social Service, the Western Australian Council of Social Service, Original Power, the First Nations Clean Energy Network, Tangentyere Council Research Hub, Indigenous Consumer Assistance Network, Weipa Community Care, Energy Consumers Australia (ECA), Australian Energy Regulator and one other who requested anonymity. Before engagement commenced, these organizations all received a project information sheet and were read a consent form script; options were offered for anonymity, attribution at organizational level and attribution at individual level.

Our initial list of indicators included life-support protections, hardship policies, protections from disconnection, redress of electricity service or access issues and access to solar; this was based on energy justice concerns identified in prior literature. Review of regulatory documents prompted re-evaluation of some of these (hardship policies were not sufficiently precise to map), and refinement of others (the only protections related to disconnection that could be identified were related to life support, extreme weather and reporting of disconnections; redress of electricity service or access issues was refined to complaints process and independence based on language used in regulatory documents). Stakeholder consultation reinforced the necessity of including access to solar, and regulatory review triangulated the need to focus on distributor contracts to establish this. In conversations with stakeholders, we also identified the need to include guaranteed service levels and family violence policies in review. Excepting these two additions, stakeholders agreed that our initial list and refinements covered the key areas of interest. Stakeholders also repeatedly reinforced the importance of an indicator to visualize whether multiple protections were absent.

Due to this primary intent of stakeholder engagement to ensure completeness of indicator selection rather than to comprise a form of data collection or a formal mode of analysis, we took detailed minutes of each stakeholder meeting but did not record or transcribe our discussions with stakeholders. Where key insights emerged from these engagements, any references included in the manuscript were double-checked with individuals for accuracy.

Data preparation for mapping and statistical analysis

The summarized legislative situation for each settlement was recorded by a team member with legal expertise. These summaries are reported in Supplementary Tables 1, 5–8 and 10–13. Detailed categories were then simplified based on agreement between at least two our team members, with summaries recorded in these Supplementary Tables.

Data underwent two steps of simplification. First, we created the categories used in individual maps (Figs. 3–5), that is, neither post-pay nor prepay customers are protected (0); no protection for prepay customers, post-pay protected (1); prepayment is prohibited, post-pay protected (2) and both post-pay and prepay customers are protected (3). Some maps required additional categories, that is, prepayment and life support are mutually incompatible (4) and procedure required for prepay but not post-pay customers (1.5).

This was then further aggregated for statistical analyses in Table 1 models 1–5, simplified to a dichotomous yes (1) or no (0), using the principle of minimum protection available to all customers in the settlement. We aggregated the map codes described in Supplementary Tables 5, 8 and 11–13. Settlements are coded 1 where all customers, that is, both post-pay and prepay, receive protection (map codes 2 and 3; life-support code 4 is coded 1 for Table 1 and 0 for Supplementary Table 3).

We coded settlements 0 where not all customers receive protection (map codes 0, 1 or 1.5). This approach extended to locations where prepay is in theory permitted but not currently in use. In such cases if the protection was not clearly available to (hypothetical future) prepay customers but was available to post-pay customers, we coded 0.

We examined whether the use of prepayment meters is expressly prohibited (prepayment prohibited) by legislation, code or licence conditions. Supplementary Table 1 describes simplified coding. In cases where prepay or equivalent meters were permitted but not currently operational, we coded 0 (not prohibited).

We examined whether protections from disconnection for life-support customers are required by legislation, code or licence condition in the event of non-payment. Supplementary Table 5 details the simplified codes and map codes assigned to each category. Life-support coding includes a '91' simplified code for prepay customers where life support and prepay are mutually exclusive. For mapping, this 91 code became either a 4 (if prepay and life support were mutually exclusive but post-pay is protected) or a 0 (if prepay and life support were mutually exclusive and post-pay is not protected). In rare cases, contracts afforded a legal protection even in the absence of legislative requirements. This is the case, for example, for remote communities served by Jacana in the NT, where Jacana offers contractual protections for life-support customers equivalent to those for communities connected to major grid networks. Our mapping of life-support protections focuses on those in legislation, code or licence condition, but we note that in certain cases customer protections may also arise at a (more changeable) contractual level.

We assessed whether there is a legal requirement for the retailer to have a family violence policy pursuant to act, regulation or code and investigated this separately for prepay and post-pay customers. Supplementary Table 6 details the simplified coding and the map code assigned to each category.

We examined whether the retailer is legally required to provide protections from disconnection for non-payment during an extreme weather event pursuant to legislation, code or licence condition. Supplementary Table 7 details the simplified codes and map codes assigned to each category.

We examine whether act, code or licence condition establishes a guaranteed service level scheme, which the distributor is legally required to adhere to, covering unplanned interruptions in the customer's electricity supply. Supplementary Table 8 details the simplified codes and map codes assigned to each category.

Legislation may provide a right to connect solar, but this is always at some degree of distributor discretion for technical and economic considerations. There is no distinction in these regulatory documents between prepay and post-pay customers. We examine the degree to which relevant legislation specifies a standard set of conditions under which the distributor is required to connect residential solar (Supplementary Table 10; this variable represents an exception to the coding scheme). We interpret the absence of a legislative right to connect or broad qualifying parameters (for example, which apply in isolated networks in Queensland) as 'high distributor discretion'. In contrast, 'moderate discretion' arises where there is a requirement for a model standing offer (for example, National Electricity Rules, Chapter 5A for NEM interconnected locations) or there are other clear qualifying parameters (for example, off-grid Tasmania).

Because legislation always allows distributor discretion in enacting customer right to connect solar, we review the connection terms in the model standing offer contracts (or equivalent) that a customer would navigate when attempting to establish a solar connection with the distributor (that is, the clarity in connecting solar). These standard contracts represent a point at which the distributor can legally refuse a connection if the residential solar system does not meet their requirements (such as by falling outside conditions specified in the model standing offer). Specifically, we consider whether these contracts articulate those conditions under which a solar connection (through the associated contract) could be applied for with a reasonable expectation of success, such as system size, and inverter requirements and export limits. Review assessed whether the contract (such as a model standing offer) that a customer would refer to when connecting solar to a distribution network had clear eligibility criteria laid out under which the consumer could reasonably expect the distributor to approve a connection request for solar. For example, Essential Energy's licensed distribution area in New South Wales has a model standing offer for basic (post-pay) connection services, and the standing offer contains the terms and conditions for solar connections—this provides clarity and was coded as '1'. Supplementary Table 11 describes the simplified coding and map coding for prepay and post-pay customers.

We examined whether act, regulation or code legally requires the retailer to report total numbers of customer disconnections for non-payment (disconnection reporting), coding separately for post-pay and prepay customers. Supplementary Table 12 reports simplified coding and map coding.

Four indicators were combined to understand minimum complaints protections. We examined the complaints resolution process and ombudsman process for both distributors and retailers to determine whether there is a requirement by act, regulation, code or licence condition for the retailer and/or distributor to (1) have and publish customer complaints/dispute resolution procedures and (2) be subject to an independent investigation and resolution process in relation to customer complaints/disputes. These protections were synonymous in most, but not all, cases. Given the similarity and close relation of these four indicators, we created a 'minimum complaints process' indicator for each settlement that was assigned the lowest value given to any of these four component indicators. We consider both prepay and post-pay protections, and Supplementary Table 13 describes the simplified coding and map coding for categories of settlement. Where procedures were not clearly required or where procedures were required but publishing or making the procedures available to customers was not, settlements were assigned a simplified code of 0. In cases where dispute resolution required retailers' participation only if requested in writing by the regulator and cases with thresholds for customer inclusion, we assigned a simplified code of 0 due to the high barrier customers may face.

Most settlements (92%) have four or five of the legal protections for life support, guaranteed service levels, solar connection, disconnection reporting and complaints process clarity and independence. Figure 2 shows distribution of these differences. We create an indicator for underserved (in multiple areas) that is coded 1 if settlements have zero to three of these protections and 0 if settlements have four to five of these protections.

Statistical analysis

Stata MP 17.0 is used for all statistical analysis. Statistical analysis is limited to those variables for which we can identify differences between post-pay and prepay customers and those variables where visible variation is found during geographic mapping. We thus exclude family violence, extreme weather and legislative degree of distributor discretion in solar connection from statistical analysis. We examine life-support protections, guaranteed service levels, solar connection clarity, disconnection reporting requirements, clarity and independence of complaints process and whether a settlement is underserved on multiple metrics. The dataset is largely the same as that used for mapping, with a further 51 settlements excluded due to lack of key socio-demographic data (IRSAD), for a final sample of $n = 2{,}996$ settlements.

Multiple logistic regression is used to assess the extent to which a settlement being remote or Indigenous (where over 80% of the population identified as Aboriginal and Torres Strait Islanders) is associated with greater likelihood of a settlement lacking each of the five tested protections and for the aggregate indicator. Stata estimates equation (1),

where p is the expected probability that the outcome is present (that is, of having a regulatory protection for either life-support protections, guaranteed service level, solar connection clarity, disconnection reporting requirements, clarity and independence of complaints process or the aggregated indicator for settlements underserved on multiple metrics); X_1 through X_4 are distinct independent variables (1, remote (dichotomous); 2, majority Indigenous (dichotomous); 3, population (continuous) and 4, IRSAD (continuous)); β_1 through β_4 are the regression coefficients associated with corresponding variables and β_0 is the intercept.

$$p = \frac{\exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4)}{1 + \exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4)} \quad (1)$$

Testing the variance inflation factor (VIF) for multicollinearity in regressions indicates VIF of 0 to 2 for each independent variable within our dataset. By most rules of thumb, this is a low VIF—generally, VIF only merits further investigation for variables over 10. Multicollinearity of our independent variables is thus unlikely to impact interpretation of our model results.

The logit command in Stata is used, providing logistic regression coefficients (not odds ratios). The margins (contrast) post-estimation command is then used to calculate the likelihood of groups lacking protections in comparison to counterparts. Interpretation of these likelihoods is that unconditional on other variables, settlements that are remote (Indigenous) are x% more likely to have protections, compared with settlements that are not remote (not Indigenous).

Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

Data availability

The data underlying this project are available via Figshare at https://doi.org/10.6084/m9.figshare.24550585. We make available both (1) the customized geographies and their associated socio-demographic data and (2) the full underlying regulatory coding, preserving the original richness before we applied our simplification criteria. The Stata do file is included in the Figshare upload for ease of adapting the data for further use. Source data are provided with this paper.

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Author contributions

L.V.W., B.R., S.W., L.O., M.K. and V.N.D. contributed to conceptualization of the research. We especially note the contributions of M.K. and V.N.D. in shaping our understanding of the key issues faced by Indigenous communities in the NT. F.M. developed the customized geographies essential to settlement identification and worked with S.W. to validate and refine this new methodology. S.W. led data curation, that is, reviewed regulatory documents and established the dataset. L.V.W. and S.W. reviewed the regulation dataset to establish and implement mapping and analysis protocols. L.V.W., S.W. and B.R. conducted three rounds of engagement and consultations with 32 intermediaries from energy, housing, health and social service organizations. L.V.W., S.W., B.R., F.M. and L.O. wrote the initial draft of the paper, and L.V.W., B.R., S.W., F.M., L.O., M.K. and V.N.D. contributed to subsequent review and revisions. L.V.W., S.W., B.R., F.M. and L.O. acquired funding for the work. L.V.W. conducted statistical analysis and geographic information systems (GIS) mapping, and her role included supervision. L.V.W. and S.W. managed project administration. F.M. contributed to GIS mapping.

Competing interests

The authors declare no competing interests.

Additional information

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Software and code

Policy information about availability of computer code

Data collection	Data was collected manually from sources identified in the manuscript, and analyzed with Stata using commands identified in the manuscript. The uploaded data set contains a comprehensive list of source documents used in coding policies for each settlement. The do file is also available on FigShare; it uses standard Stata commands, and is provided primarily for ease of reproducing our dichotomous indicators from the detailed data.
Data analysis	Stata MP 17.0 is used for all statistical analysis.

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The data underlying this project is made fully available through Figshare. We have made available both 1) the customised geographies and their associated

sociodemographic data, and 2) the full underlying policy coding, preserving the original richness before we applied our simplification criteria. We ask that this data set be cited if used in future work. Please contact the corresponding author with any questions.

The data set can be accessed at the DOI 10.6084/m9.figshare.24550585. The dataset should be cited as White, L.V., Riley, B., Wilson, S., Markham, F., O'Neill, L., Klerck, M., Davis, V.N. (2023) Electricity retail regulation in Australian settlements focusing on residential consumer protections and providing sociodemographic and remoteness indicators. DOI 10.6084/m9.figshare.24550585

Human research participants

Policy information about studies involving human research participants and Sex and Gender in Research.

Reporting on sex and gender	Not Applicable. We engaged with to several stakeholder organisations, but we do not analyse the characteristics of individuals. Our unit of analysis is settlement level electricity retail regulation.
Population characteristics	We engaged with 12 organisations identified as being key stakeholders, including state and territory-based Councils of Social Service, First Nations organisations and policy and regulatory authorities. These were the Northern Territory Council of Social Service (NTCOSS), the South Australian Council of Social Service (SACOSS), the Western Australian Council of Social Service (WACOSS), Original Power, the First Nations Clean Energy Network (FNCEN), Tangentyere Council Research Hub, Indigenous Consumer Assistance Network (ICAN), Weipa Community Care, Energy Consumers Australia (ECA), Australian Energy Regulator (AER), and one other who requested anonymity.
Recruitment	We engaged with several organisations actively involved in strengthening rights of household energy consumers and the available consumer protections for remote and regional consumers. We identified an initial list of organisations based on our existing networks and work in this space (1. South Australian Council of Social Service (SACOSS), 2. Northern Territory Council of Social Service (NTCOSS), 3. Original Power, and 4. Energy Consumers Australia (ECA)). In initial engagement with these organisations, we identified several other key organisations to arrive at the list of 12 as above.
Ethics oversight	This research was conducted with ethics approval from the Australian National University's Research Ethics Committee approval 2022/ 443 and in accordance with the National Health and Medical Research Council's National Statement on Ethical Conduct in Human Research.

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Study description	The data used for analysis is quantitative. We used document review to identify electricity retail regulations for 12 indicators across 3,047 settlements across Australia. Statistical analysis was used to assess correlations between settlement characteristics and presence or absence of regulatory protections for the 2,996 settlements where we could match sociodemographic data. We engaged with several key organisations (as above) to give context to our analytical work.
Research sample	Our unit of analysis is settlements across Australia. We built an original data set of regulatory protections by reviewing 284 legal documents to determine protections, and over 800 further documents to cross-check regulatory context of each settlement. Legal and regulatory documents were sourced on-line, as detailed in the Methods section. Our sample of 3,047 settlements with regulatory documents mapped covers essentially all settlements in Australia. This count of 3,047 excludes 42 settlements that had unusual and poorly documented regulatory arrangements. Our sample for statistical analysis was slightly smaller (n=2,996) due to lack of sociodemographic data for 51 settlements.
Sampling strategy	We did not sample a sub-set of Australian settlements, but rather aimed to map regulatory arrangements for every settlement in Australia. There are 1,809 settlements identified in the Australian Bureau of Statistic's 2021 Urban Centres and Localities dataset, which is a recognised Australia-wide dataset for settlements with populations over 200. We created a customised geographic identification strategy to capture those settlements too small to be labelled in the Australian Bureau of Statistic's standard Urban Centres and Localities data set, and identified a total of 3,089 settlements across Australia. Our regulatory mapping covered 3,047 of the 3,089 settlements identified by our customised geography. Settlements that we could identify geographically were only excluded from policy mapping if they lacked clear regulatory documents and represented highly unusual cases (n=42). Indicators for coding were developed iteratively during three rounds of engagement and consultations with 32 intermediaries from energy, housing, health and social service organizations operating at national and sub-national levels representing a diversity of constituents and locations. We engaged with 12 organisations identified as being key stakeholders, including state and territory-

based Councils of Social Service, First Nations organisations and policy and regulatory authorities. These engagements informed analyses, but do not underpin our geographic or statistical methods, nor did these engagements shape the selection of settlements included in analysis.

Data collection

We collected data on settlement regulatory arrangements by reviewing 284 legal documents. These documents were assigned codes on the basis of the protections offered, and these codes were recorded in an Excel spreadsheet. We mapped twelve categories of regulatory protections, determined through literature review and stakeholder consultation as described in the Methods section. Settlements were coded based on their regulatory arrangements up to and including 1 July 2022. Our review began by identifying those documents applicable to each settlement nationally following a two-step process, with some iteration. We first identified the acts, regulations, rules, determinations, and orders governing electricity supply to residential customers in Australia. Second, we identified any licences, exemptions, codes, and guidelines that form part of the regulatory frameworks; in many cases these documents identify settlements by name which subsequently facilitated coding at settlement level.

Researchers were not blinded to the experimental condition or to the study hypotheses.

In engagement with stakeholders, our aim was to ensure completeness, so as to be confident we have not overlooked key regulatory disparities impacting community interests. Due to this primary intent of stakeholder engagement to ensure completeness of indicator selection rather than to comprise a form of data collection or a formal mode of analysis, we took detailed minutes of each stakeholder meeting but did not record or transcribe our discussions with stakeholders.

Timing

Data collection was completed during October 2021 to February 2023. We recorded regulatory arrangements as of 1 July 2022, to coincide with the start/end of the Australian tax year.

Data exclusions

We excluded 42 settlements that had unusual and poorly documented regulatory arrangements. A further 51 settlements were excluded from statistical analysis due to lack of sociodemographic data, specifically the indicator for Index of Relative Socio-economic Advantage and Disadvantage.

Non-participation

We used document review to underpin empirical analyses. No participants dropped out/declined participation.

Randomization

We did not use a randomisation strategy, because our mapping aimed to cover every settlement in Australia. Our statistical analyses are correlational, and do not contain treatment and control groups.

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