

Validity of energy social research during and after COVID-19: challenges, considerations, and responses

Abstract

Measures to control the spread of coronavirus disease 2019 (COVID-19) are having unprecedented impacts on people's lives around the world. In this paper, we argue that those conducting social research in the energy domain should give special consideration to the internal and external validity of their work conducted during this pandemic period. We set out a number of principles that researchers can consider to give themselves and research users greater confidence that findings and recommendations will still be applicable in years to come. Largely grounded in existing good practice guidance, our recommendations include collecting and reporting additional supporting contextual data, reviewing aspects of research design for vulnerability to validity challenges, and building in longitudinal elements where feasible. We suggest that these approaches also bring a number of opportunities to generate new insights. However, we caution that a more systemic challenge to validity of knowledge produced during this period may result from changes in the kinds of social research that it is practicable to pursue.

Keywords: Social science, energy, validity, COVID-19

Validity of energy social research during and after COVID-19: challenges, considerations, and responses

Michael J. Fell, UCL Energy Institute, University College London, Gower Street, London, UK. michael.fell@ucl.ac.uk (corresponding author)

Laura Pagel, Swiss Center for Affective Sciences, University of Geneva, Switzerland. Laura.Pagel@etu.unige.ch

Chien-fei Chen, Center for Ultra-wide-area Resilient Electrical Energy Transmission Networks (CURENT), University of Tennessee, USA. cchen26@utk.edu

Matthew H. Goldberg, Yale Program on Climate Change Communication, Yale University, USA. matthew.goldberg@yale.edu

Mario Herberz, Department of Psychology and Swiss Center for Affective Sciences, University of Geneva, Switzerland. mario.herberz@unige.ch

Gesche M. Huebner, UCL Energy Institute and Institute for Environmental Design & Engineering, University College London, UK. g.huebner@ucl.ac.uk

Siddharth Sareen, Department of Geography & Centre for Climate and Energy Transformation, University of Bergen, Norway. Siddharth.Sareen@uib.no

Ulf J. J. Hahnel, Department of Psychology and Swiss Center for Affective Sciences, University of Geneva, Switzerland. Ulf.Hahnel@unige.ch

Acknowledgements

While this work did not receive any dedicated funding in its own right, the individual authors gratefully acknowledge funding as follows. Michael Fell: UK Research and Innovation through the Centre for Research into Energy Demand Solutions (EP/R 035288/1) and the Energy Revolution Research Consortium (EP/S031863/1). Chien-fei Chen: the Engineering Research Center Program of the U.S. National Science Foundation (NSF) and the Department of Energy under NSF award EEC-1041877 and the CURENT Industry Partnership Program. Gesche Huebner: UK Research and Innovation through the Centre for Research into Energy Demand Solutions (EP/R 035288/1). Siddharth Sareen: Trond Mohn Foundation project 'European cities as actors in climate and energy transformation'. Ulf J. J. Hahnel: SCCER CREST (Swiss Competence Center for Energy Research), supported by the Swiss Innovation Agency (Innosuisse). The authors declare no competing interests.

Validity of energy social research during and after COVID-19: challenges, considerations, and responses

Abstract

Measures to control the spread of coronavirus disease 2019 (COVID-19) are having unprecedented impacts on people's lives around the world. In this paper, we argue that those conducting social research in the energy domain should give special consideration to the internal and external validity of their work conducted during this pandemic period. We set out a number of principles that researchers can consider to give themselves and research users greater confidence that findings and recommendations will still be applicable in years to come. Largely grounded in existing good practice guidance, our recommendations include collecting and reporting additional supporting contextual data, reviewing aspects of research design for vulnerability to validity challenges, and building in longitudinal elements where feasible. We suggest that these approaches also bring a number of opportunities to generate new insights. However, we caution that a more systemic challenge to validity of knowledge produced during this period may result from changes in the kinds of social research that it is practicable to pursue.

Keywords: Social science, energy, validity, COVID-19

Introduction

The coronavirus disease 2019 (COVID-19) pandemic is having tragic health consequences around the world, and measures to combat it are impacting people's lives in unprecedented ways. There is, as yet, no clarity on when and how measures such as suspension of certain businesses and physical distancing might end completely, or need to be reintroduced. The timescales required to develop a vaccine and deploy it globally suggest this could be well into 2021 and possibly later.

During this time, the validity of energy social science research faces additional threats. Validity generally refers to the truth of a knowledge claim or inference [1]. National and global events continuously shape social worlds. But the magnitude, speed, and reach of the changes to our lives are of a different order to anything that most people alive today have experienced. Given the scale and rapidity of change, how can we ensure that conclusions drawn from data collected during the pandemic are valid, representative, generalisable to a post-pandemic world, and comparable to the pre-pandemic one?

While the answer is inherently unknowable [2], our aim in writing this paper is to highlight principles that we believe energy social science researchers can take to help mitigate this

1 uncertainty, and ease future interpretation of research findings in the context of the
2 progressing pandemic. Broadly speaking, these principles involve giving consideration to
3 possible impacts of the pandemic and associated response measures on findings; adjusting
4 research design and data collection to reflect this; and reporting extra contextual detail. We
5 argue that researchers who take reasonable steps in these areas will be able to ensure
6 greater confidence in the validity of the work they conduct during this period. Through
7 consciously enhanced transparency for the 'extended peer community' that post-normal
8 science scholars have long espoused [2,3], their contributions will be better positioned to
9 help address future challenges on the validity of findings by reviewers and users.

12 We co-produced these principles as energy researchers who represent a variety of relevant
13 disciplinary perspectives and subject interests, and are based in a range of institutions and
14 countries. This allowed us to balance the will to draw on a breadth of input across the field,
15 with the need to share these principles in a timely fashion. We set them out in the hope that
16 researchers will find them helpful, but recognise that applicability will vary across energy
17 social science research. Our recommendations are likely to be most applicable to
18 researchers employing quantitative research methods that are often restricted in the amount
19 of contextual data they are able to collect [4]. However, we hope that as a set of
20 considerations they will be helpful to a broad range of energy social science scholars to
21 employ as they see fit.

26 The next section of this paper sets out the key challenges we identify for validity during the
27 COVID-19 pandemic, and justifies our focus on social science research in energy. We then
28 expand on steps that researchers can take to address these challenges, and provide a
29 simple checklist that can be applied by scholars in order to address the impacts of the
30 pandemic on their research. We finally highlight additional opportunities these steps can
31 yield, but also point out important potential implications for the nature of knowledge
32 generated by contemporary research.

37 Challenges to validity

41 Decisions about validity inherently concern tradeoffs and priorities of a given research study
42 [1]. For instance, a researcher might prioritize internal validity (or "the degree to which a
43 study establishes the cause-and-effect relationship" [5]) by conducting a randomized
44 controlled laboratory experiment. Artificial laboratory conditions enable strong experimental
45 control, but limit generalizability across diverse, complex real-world situations. A field study,
46 in contrast, might prioritize external validity (or "the generalization of research findings [...] to
47 settings and populations other than those studied" [6]), but surrenders some ability to control
48 and measure variables.

51 Both of these forms of validity are important. If we cannot trust the findings of a study
52 because of methodological problems or unaccounted-for variables, generalisability is
53 irrelevant. And findings that only apply in exceptionally narrow circumstances offer very
54 limited value in applied research settings. External validity tends to be given special weight
55 in applied research, including most energy research, where the generalisability of findings,
56 and therefore any resulting conclusions and recommendations for action, often has primacy.

1 Our point of departure here is the impact of the COVID-19 pandemic and associated
2 response measures on internal, external, and subsidiary forms of validity. We argue that the
3 pandemic merits explicit consideration for validity for a number of reasons. First, the
4 response to COVID-19 represents a departure from ordinary circumstances that is
5 unprecedented in terms of its global nature, rapidity, diversity, and severity of impacts. At the
6 time of writing in May 2020, over 100 countries and several billion people were under some
7 form of lockdown, with restricted rights to movement and public assembly. In many cases,
8 schools, non-essential businesses and hospitality venues were closed. Evidence of
9 prevalent psychological distress and anxiety had begun to emerge [7,8]. Such a situation is
10 far removed from the conditions under which knowledge is ordinarily produced and applied,
11 and questions around the validity of findings generated during this circumstance are
12 inevitable.
13
14

15
16 Second, an important consideration for external validity is how stable findings are over time.
17 While there is always uncertainty about how closely the future will resemble the present, we
18 argue that this uncertainty is now especially high. Movement restrictions have already left
19 millions of people unemployed, with millions more at risk of losing their jobs as businesses
20 contract or close [9]. Governmental support packages are building up unprecedented levels
21 of national debt that will have to be paid for, with little clarity around the effect this will have
22 for public services and taxes. While some effects such as quarantine measures will be
23 shorter-term, it is unknown whether the pandemic itself and associated consequences will
24 result in long-term effects on the individual and societal level. Realistic and symbolic threats
25 induced by the pandemic are likely to affect individuals' values, identity, and worldviews and
26 thus could exert long-term effects on various dimensions [10]. Moreover, research on past
27 societal crises has shown that pandemic-related effects such as large-scale unemployment
28 can lead to long-term effects on mental health [11]. Taken together with the scale of current
29 impacts, we believe this increased uncertainty in the short, medium, and long term justifies
30 special consideration of validity of social research and, furthermore, a higher burden of proof
31 on claims to such validity.
32
33
34
35
36
37

38 Why is a particular focus on energy studies important? Energy use plays a prominent role in
39 many aspects of human life. Any changes on the scale being experienced during the
40 pandemic have significant impacts not only on patterns of interaction with energy systems,
41 but also on how people relate to and prioritise those systems. Much energy research
42 conducted today aims to inform transitions to clean, low-carbon energy systems that work for
43 people and society. Although research conducted now can shed light on how the
44 extraordinary measures in place might impact energy use (such as evidence of reduced
45 weekday electricity use [12] and changing usage patterns [13]), it is challenging to
46 disentangle these impacts from those that result from measures deployable absent a
47 pandemic. Moreover, the impact of such a drastic, globally shared experience impacts
48 discursive and normative registers, with undetermined implications for public commitment to
49 low-carbon energy transitions that become interwoven with other drivers of change
50 pathways.
51
52
53
54
55

56 Although many of the principles we set out next could simply be viewed as good research
57 practice, we think that they merit explicit attention during this pandemic and its aftermath.
58 We argue that they are especially important for those domains of energy social research that
59 claim broad generalisability to their findings and insights, with limited focus on context. For
60
61
62
63
64
65

1 example, we think the points raised here are generally more applicable to survey-based than
2 ethnographic research. By bringing these recommendations together here, we hope to
3 stimulate a more consistent response by social researchers, allowing greater
4 commensurability and comparability across studies in the future. Furthermore, we recognise
5 that scholars using social research approaches in energy have a wide variety of
6 backgrounds and levels of experience. What we suggest may be self-evident to some,
7 although for these we hope it will be helpful to have a checklist to compare their own
8 responses against. To others, we hope it will provide both a prompt to consider challenges to
9 validity, and a handy set of responses to consider.
10

11 Principles to consider for validity

12 We have argued that challenges to the validity of social science energy research presented
13 by the COVID-19 pandemic warrant special recognition. We now lay out a set of principles
14 for researchers to consider bringing to their practice for the duration of the pandemic period
15 and its aftermath to help bolster the validity of their work, and to ensure that future use of
16 their findings and recommendations is facilitated by requisite information to aid correct
17 interpretation. Our recommendations address data collection and the reporting of study
18 conditions and context, as well as considerations for study designs in order to ensure high
19 validity of energy social science research conducted during and after the pandemic. Given
20 the large number of possible new factors to be taken into account, we propose a '*core and
21 consider*' approach, allowing researchers in the field to prioritise and justify the measures
22 they want to take to account for potential pandemic-related influences.
23
24
25
26
27
28
29
30

31 Where possible, we have drawn on existing good practice guidance, which itself has
32 developed through conventional processes of cross-field engagement [14]. While we think
33 the validity challenges we have raised here are important, we also recognise that any
34 responses to them must fit within existing research plans, budgets, timelines, labour
35 constraints, and the heightened need for affective care, including researchers' own well-
36 being under personal stress-inducing conditions. Any response must be both proportionate
37 to the anticipated vulnerability to validity challenges of the kind set out in the previous
38 section.
39
40
41
42

43 Ethical and data protection concerns, while not directly related to validity, must be borne
44 prominently in mind. Any changes to planned research should not, unless it is explicitly
45 justified, introduce collection of categories of data that are more sensitive than those that
46 were originally (or would ordinarily be) planned and/or approved. This means, for example,
47 that researchers should not (without careful thought and justification) begin to collect data on
48 physical or mental health unless this was intended anyway. Researchers should be mindful
49 of the extra burden to participants that introducing additional data collection could bring.
50 Extra sensitivity is called for on the part of researchers to the potential impacts of collecting
51 data on topics which may be more upsetting now than would ordinarily be the case.
52
53
54
55

56 Capture and report on extra relevant data

57 We suggest that additional and/or modified variables may need to be collected and reported
58 for studies carried out during or after the COVID-19 pandemic in order to account for the
59
60
61
62
63
64
65

1 impact of the pandemic on research validity. Already, researchers should – and many do –
2 report contextual factors of any study, and consider how these might impact the study
3 findings [15–17] . Given the large number of possible new factors to be taken into account,
4 we suggest researchers take a ‘*core and consider*’ approach. Government restrictions and
5 relevant demographic variables at the level of the unit of analysis (e.g., individuals or
6 households) are *core additional variables* that should be reported and discussed. Other
7 factors should be *considered* for additional reporting depending on the precise topic of
8 research.
9

10
11 As in all studies, reporting of contextual factors should encompass date(s), place(s), and
12 duration of data collection. As a core concern, we suggest that this should now be
13 supplemented with information on pandemic-related national and local policies that were in
14 force at the time and place of data collection. This could include factors such as levels of
15 restriction of people’s freedom to move around outside the home, including self-imposed
16 precautionary behaviour, and the open/closed status of specific relevant services such as
17 schools and certain businesses. Significant changes in any of these measures during data
18 collection should also be reported. Researchers may consider it to be important for context
19 to give a sense of the severity of the pandemic (including health, social and economic
20 impacts, as relevant). We suggest using official government references for a description of
21 such policies and impacts where possible, in ways that are cognizant of their rapid temporal
22 evolution.
23
24
25
26
27

28 A further core consideration is that local and national pandemic response measures affect
29 individuals and households in diverse ways; specifying the national policies during data
30 collection alone does not explain effects at the individual (or other analytical) level. More
31 specific effects can be captured by measuring application of and compliance with response
32 measures on the respective analytical level, and/or through collection of additional
33 demographic variables from which application could be inferred. The nature and detail of
34 measures will differ by locality, but could include whether someone is considered a ‘key
35 worker’ (and hence still regularly leaves the home during lockdown) or comes under a high-
36 risk category and has to observe stricter measures. Other standard demographic variables
37 may need amendment depending on the study aims. For instance, employment status can
38 include categories such as being placed on government-subsidised furlough, working
39 reduced hours, or working fully from home.
40
41
42
43
44

45 Other variables that might ordinarily have been judged as having limited importance, might
46 gain relevance. Impacts of the COVID-19 pandemic are thought to be exacerbating existing
47 inequalities in many societies, such as energy poverty issues [18]. A key variable in many
48 studies will likely be the financial situation of the individual, household, or other unit of
49 interest. Capturing information on recent (and risk of future) changes in factors such as
50 income (including transfer payments), changes in employment status, increased receipt of
51 benefits, or self-reported financial satisfaction may take on greater importance. Unexpected
52 deprivation from work income may have differential effects on energy-related measures,
53 relative to foreseeable prolonged unemployment periods; while this is a consideration in
54 samples at any time, it is likely to be especially common now. Differentiated impacts on
55 variables such as health, income or employment situation are already evident across
56 individuals, notably across ethnicities, gender and income groups [19,20]. Disaggregating on
57
58
59
60
61
62
63
64
65

the basis of such variables, while always beneficial, may now be of more acute importance given heightened inequalities.

At the individual level, we anticipate that COVID-19 response measures will be associated with important changes in behaviour, as well as cognitive, affective, and other social and material dimensions [21]. Changes in energy-related behaviours and decision-making due to changes in daily routines, work and mobility might be more apparent and measurable, but changes in decisions and actions triggered by pandemic-related shifts in energy-related beliefs, attitudes, emotions, and judgments may be just as important to apprehend. For energy social science research focusing on the aforementioned dimensions it is important to assess to what extent these variables are different from a “normal” scenario and whether potential changes are durable or ephemeral. Epidemiological research demonstrates the effect that pandemic response measures and consequences such as unemployment exert over time on personal well-being [11]). While empirical research on specific COVID-19 measures is emergent, existing theoretical research on the psychological consequences of the crisis indicates that the fallout on current generations will linger in complex ways over time [10]. The inability to accurately predict how such changes might be associated with energy-relevant outcomes, or which changes might be more or less enduring [22] , makes it all the more important to capture and consider them in the long run.

Where additional measures are included, we suggest the use of standardized approaches to the extent possible, such as widely used and validated scales employed in regular national surveys. This will allow commensurability with pre-COVID-19 levels, while minimising construct and instrument validity challenges and the resource-intensive efforts associated with developing new measures (which require substantial testing to ensure scale reliability and validity).

We show an initial mapping of variables as ‘core’ and ‘consider’ , in Table 1. We also provide a checklist (see Appendix) suggesting where and how to report those additional variables (and other considerations) in studies.

Table 1. *Core dimensions affected by the pandemic and measures to address them, distinguished between core and consider variables.*

Dimension	Related concepts	Research design measures	Core or Consider (and possible field(s) of application)
Contextual: Response measures and impacts	- Details of of national and local pandemic-related policies (e.g. measures of lockdown at the time of data collection) - Changes in national and local context (e.g. economic, social, health)	- Add objective data from media, governmental sources, databases	Core for all research.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

Demographic	<ul style="list-style-type: none">- Level of restrictions applying to individual participant (eg. categories such as key worker)- Changes in household situation (e.g., income, employment, household size)- Differentiated effects (e.g. gender, ethnicity)	<ul style="list-style-type: none">-Collect and report additional demographic variables if needed- Add subjective measure of level of restrictions applying to individual- Adapt or add in questions to capture self-reported changes in household situation- Add control variables to capture differentiated effects	<ul style="list-style-type: none">- Some likely core for all research.
Behavioral	<ul style="list-style-type: none">- Changes in (energy-relevant) behaviours and daily routines as a result of COVID-19 restrictions.- Changes in appliance use, travel behaviours, energy related purchase behaviours, etc.- Changes in other activities such as caring, volunteering, etc.	<ul style="list-style-type: none">- Add standardized control questions to assess self-reported changes in behaviour on the individual levelAdd objective measures such as energy consumption and mobilityAdd qualitative measures to assess changes in daily routines on the individual levelCompare, if possible, data with pre-pandemic data	<ul style="list-style-type: none">Consider, especially for:<ul style="list-style-type: none">- Research on household, work and mobility energy consumption- Research on energy investment decisions
Cognitive and Affective	<ul style="list-style-type: none">- Perceived personal impact of pandemic and measures- Perceived personal constraints vs. benefits due to the pandemic and measures- Perceived uncertainty- Changes in goal and priorities- Positive vs. negative affect towards personal and societal impacts of the pandemic/measures- Distinct emotions toward personal and societal impacts (e.g. worried, hopeful, sad, scared, guilty, stressed, relaxed)	<ul style="list-style-type: none">- Add standardized control questions to assess subjective cognitive and affective experiences of the crisis on the individual level- Compare, if possible, data with pre-pandemic data	<ul style="list-style-type: none">Consider, especially for:<ul style="list-style-type: none">- Research on energy-related judgements and decisions

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

Social	<ul style="list-style-type: none">- Changes in social connection/identity/norms- Perceived need for social proximity- Changes in energy burden, energy technology accessibility for underserved community- Changes in community environmental impact or climate change concerns- Perceived fairness of social distancing policy- Changes in clean energy industry & market	<ul style="list-style-type: none">- Add standardised control questions to assess subjective changes in social relationships of the crisis on the individual and group level- Add qualitative measures to assess changes in social relationships on the group level- Compare, if possible, data with pre-pandemic data	Consider, especially for: <ul style="list-style-type: none">- Research on social networks and community schemes and energy behavior-Research on energy burden, technology accessibility, and affordability.-Research on impacts on under-served communities (e.g, seniors, low-income, minority, differently-abled people)
Material/technical	<ul style="list-style-type: none">- Material changes in homes, workplaces connected with the pandemic (e.g. IT equipment for home working, clothing)- Digital changes such as service subscriptions (e.g. for video conferencing), cyber security issues	<ul style="list-style-type: none">- Add standardised questions	Consider, especially for: <ul style="list-style-type: none">- Research on household, work and mobility energy consumption- Research on energy investment decisions

Consider implications for design, conduct and interpretation of research

When thinking about the potential effects of the COVID-19 pandemic on the validity of research findings, it is also important to consider how it might affect research design. In this section, we briefly introduce issues relating to study design, sample selection and recruitment, and data collection methodology, as well as implications for interpretation of findings. Suggestions on ways to report such considerations are also provided in the checklist (see Appendix).

Study design

It is likely that the pandemic will affect *non-experimental research* in different ways than it will affect *experimental research*. Research focused on identifying associations might be especially vulnerable to threats to internal and external validity. More specifically, if the pandemic affects both the independent and dependent variables of interest, it can induce a spurious correlation (confounding; [23]). For instance, the pandemic might harm mental health *and* increase energy usage, making it appear as though the variables are related when they might not be, absent the pandemic. Researchers can address this concern in the way that is typically recommended for addressing confounding: anticipate how the pandemic might affect your variables of interest, measure this set of variables, and test whether they affect the study's primary results [24,25]. The idea that 'correlation is not causation' is well-known -- but worth keeping salient especially at times when non-experimental research is being planned or altered at short notice.

1 Experimental designs are still potentially vulnerable to other pandemic-induced issues.
2 Experiments, by design, manipulate a specific variable of interest. For example, an
3 experiment aiming to improve people’s motivation to purchase or support renewable energy
4 by means of messaging strategies might focus on the harm caused by fossil fuels to
5 increase people’s fossil fuel risk perceptions. However, the salience of such risks, and
6 therefore their malleability, may be substantially decreased if people are preoccupied with
7 other worries related to COVID-19. Thus, researchers should consider such influences and,
8 if possible, take measures to ensure that they can indeed manipulate the causal variable of
9 interest in an effective and meaningful way. This is an empirical question for each
10 manipulated variable, but we advise that researchers attempt to anticipate such issues and
11 design their research accordingly.
12
13
14
15

16 A clear consequence of the pandemic is that it will make it more difficult to conduct between-
17 and within-country comparisons where COVID-19 impacts and restrictions are different. For
18 example, home energy usage will be higher in places where people are required to stay at
19 home. A useful rule of thumb is, wherever reasonably possible, researchers should
20 contextualize their research by considering how political and cultural circumstances might
21 affect their results (see section “Capture and report on extra relevant data”; [15]). It would be
22 even better to anticipate how such factors might affect results and design the study to
23 mitigate them, such as collecting a sample that is relatively homogeneous in orders to stay
24 at home, limit travel, or any variable that might substantively affect the results. If substantial
25 heterogeneity of restrictions is anticipated within a sample, increasing sample size to
26 maintain statistical power should be considered.
27
28
29
30

31 Independent of study type, a powerful way to get a measure of stability and validity of
32 findings over time is to build *longitudinal* elements into the research design. First,
33 researchers could consider building replications into their research plan. This can be done
34 by intentionally splitting data collection over waves separated by a period of time. This allows
35 for comparison of the variables of interest over the two waves. Variables that remain
36 constant over this period are likely to be relatively less affected by pandemic response
37 measures than those which show variation. This approach lends itself particularly well to
38 collaborations between research groups, which could consider teaming up to add variables
39 of interest reciprocally onto the end of each other’s studies, saving on budget and potentially
40 introducing opportunities for new analyses. Please refer to the section “Capture and report
41 extra relevant data” for more information on variable dimensions to consider.
42
43
44
45
46

47 Another possible approach to demonstrate the robustness of research findings over time
48 could be through attempting to reproduce previous research findings -- either of related
49 research by the researcher themselves, or of previously well-reproduced effects. The extent
50 to which previous findings are reproduced, or change, could help ‘calibrate’ the more recent
51 research and give some insight into whether or not the domain of interest is more or less
52 impacted by the pandemic and the corresponding response (also accepting that failure to
53 reproduce findings is not an unusual occurrence even under normal circumstances [25]).
54
55
56

57 *Data collection methodology*

58 Data collection with a given research method could produce different findings now compared
59 to before pandemic-related restriction measures were put into place. For example, research
60
61
62
63
64
65

1 conducted online could be more heavily influenced by distracting factors of the participant's
2 environment. Where people are confined to their homes, completing a survey or conducting
3 an interview in a standardized way might be more difficult than before. This consideration is
4 especially important, since persisting restrictions of contact might result in a shift towards
5 more research being conducted online versus in person. It is thus recommended to explore
6 the possibility of using more than one method to investigate the same research question,
7 and to record potential limitations specific to a data collection method to account for their
8 influence on the validity of the findings. This is another area where collaboration between
9 research groups with complementary interests could bring significant additional value by
10 allowing testing of the same research question through different approaches and in different
11 settings [27–29]. While elaborating on additional or alternative methods, it is again important
12 to consider ethical aspects. As mentioned earlier, the extra sensitivity of collected data has
13 to be thought through, and in terms of data collection methods, researchers and analysts
14 should make sure that data privacy and confidentiality is not undermined by new approaches
15 [30].
16
17
18

19 *Interpreting findings and making recommendations*

20 In the previous subsection we already highlighted the importance of giving due consideration
21 to contextual factors. In respect of COVID-19, this means paying particular attention to the
22 extent to which pandemic response measures (and changes in them across time and the
23 sample) might have contributed to the observation of particular results. If possible,
24 researchers should attempt to communicate and justify their best estimate as to the impact
25 such factors could have had on findings. For example, if little systematic difference is
26 observed in an outcome variable across groups who were substantially differently impacted
27 by pandemic response measures, this could be offered in support of a case that the impact
28 of COVID-19 of that particular variable could be small. As in many areas of research,
29 transparency is likely to be key in allowing users to make informed judgements of their own.
30 Any recommendations for policy, practice, or further research should be similarly transparent
31 and include appropriate caveats on the context of the findings to which they relate.
32
33
34
35
36
37
38

39 Opportunities for research

40 Employing the principles set out above presents a number of opportunities that go beyond
41 simply mitigating threats to validity, and could help generate new insights or improve
42 research practice in general. The introduction of longitudinal elements can provide important
43 insights on stable and dynamic determinants of energy-relevant outcomes, especially if
44 combined with new contextual, behavioural, and other data that may not previously have
45 been collected. Such longitudinal studies could moreover contribute to the research question
46 whether observed changes on the individual and societal level are caused by the pandemic
47 itself (e.g., due to perceived threats and vulnerability) or by associated measures and
48 consequences (e.g., due to lockdown and job loss) and thus provide insights into short-term
49 and long-term effects of the pandemic. Moreover, where collected data suggests that
50 different groups of people have been (or will be) systematically exposed to different
51 conditions as a result of the pandemic, natural experiments could be possible. Natural
52 experiments provide a powerful opportunity to investigate causal associations which may
53 otherwise be difficult or impossible to control for (for an example see: [31]). These fleeting
54 windows of opportunity can provide novel research opportunities and should be considered
55
56
57
58
59
60
61
62
63
64
65

1 by energy researchers. The same window of opportunity will likely extend to policy
2 interventions introduced in the wake of the pandemic to aid economic recovery.

3
4 We already highlighted the possible benefits that could accrue from collaboration with other
5 groups to facilitate replication and support validity, but there is also a wider convergence
6 research opportunity in energy social studies during and after COVID-19. Convergence
7 research is a way of addressing complex problems through highly integrated interdisciplinary
8 approaches [32]. Given the range and scale of current and anticipated impacts of the
9 pandemic, such an approach is likely to be especially valuable, and opportunities to build
10 inter- and transdisciplinary collaborations should be proactively sought. Such collaboration
11 may also provide a route to adding in important contextual data, for example through
12 matching datasets.
13
14

15
16 Finally, we suggest that responding to validity challenges presented by the COVID-19 crisis
17 is an opportunity for the energy research field to step up and embrace practices around
18 transparency and reproducibility that are now seen as standard practice in other areas of
19 research. For reasons likely connected with the multidisciplinary and applied nature of most
20 energy research, tools such as reporting guidelines and pre-registration of analysis plans are
21 still rarely employed [33]. It is possible that the particularly pressing need to demonstrate
22 validity at present will result in familiarity with, and adoption of, tools that subsequently
23 become standard practice for an increasing number of energy researchers, potentially
24 enhancing the overall validity of research in the field.
25
26
27
28
29

30 Body of knowledge validity

31
32 In much of the social sciences, knowledge on the most severe and pressing problems is
33 often difficult to create and therefore constitutes a smaller proportion of thematic scholarship
34 than its implications merit. The flip side of this is that 'low-hanging fruits' can suffer from
35 excessive coverage. This impacts the 'body of knowledge' validity, which we define as the
36 representativeness of research in a field relative to the real-world problems the field is
37 concerned with [34]. Energy social science research, with its diverse methodologies, spatial
38 and scalar foci, and associated differences of requisite time and effort, is no stranger to
39 these tendencies. Consider, for instance, the wealth of scholarship on local and urban
40 energy initiatives in the UK, home to many energy research scholars, versus the relatively
41 thin body of work on energy practices in rural Sub-Saharan Africa. Both issues merit
42 attention and are generative for conceptual insight, but the latter affects over a billion people,
43 many of whom experience relatively severe degrees of energy poverty, and yet hardly
44 registers in terms of volume in relevant energy social science research. We detect a risk that
45 curtailment of field-based empirical research, especially in regions that face severe energy
46 challenges and may be heavily impacted by the epidemic, will exacerbate existing biases in
47 representation in terms of volume (more desk study over ethnographic research than usual),
48 methodology (potentially more conceptual work over evidence-based research) and regional
49 coverage (less pandemic-impacted areas over more pandemic-impacted areas).
50
51
52
53
54
55
56

57 To some extent, this is a perennial problem in any interdisciplinary or transdisciplinary field
58 of study: ethnographic work in challenging regions with marginalised populations takes time
59 and the classics on such topics that have accumulated over the years (in quite large
60
61
62
63
64
65

1 numbers) consequently receive considerable attention. It is similarly evident in other fields of
2 energy research, such as modelling, and outside of the energy domain. Yet research today
3 is heavily metricised, and most scholars with access to most global peer-reviewed
4 scholarship are based in Global North institutions and typically urban contexts, often with
5 pressure to publish frequently. This leads to the double jeopardy of being pressed for time to
6 focus on short-term impact, and of being far more likely to access highly-cited and high-
7 volume segments of the scholarship one engages with. Since the pace of research outputs
8 has escalated, few scholars are positioned to navigate a body of knowledge with adequate
9 care to balance its in-built biases of representation.

10
11
12 Already, we see moves to run online surveys and study social perceptions; even with all the
13 appropriate caveats and the best of informed intentions, these contribute to a likely
14 disbalance by volume of the sort of concerns that will get platformed in energy research
15 journals in the short- to medium-term. How much coverage of marginalised, hard-to-access
16 concerns - such as migrants cast adrift with little energy access, subsistence farmers with
17 crop loss and inability to pay for fuel costs - will be lost and substituted by low-hanging fruit?
18 Such exacerbation of an existing bias can cloud future accounts and understandings of the
19 true effects of a pandemic on the subject of energy research, i.e., on the global lived
20 experience of energy. But it is not inevitable - it is an artefact of choices we make as an
21 epistemic community. Informed by recognition of likely biases, our choices (and those of
22 funders, who can prioritise research on marginalised research areas) can embody normative
23 commitment to proportionally match research coverage to real-world problems. We can
24 productively draw on approaches such as convergence research highlighted above. This
25 drive captures the essence of our contribution, which is to work toward a reflexive
26 understanding of our role as a scholarly community at this time of crisis and opportunity.

33 34 Conclusion

35
36
37 In this paper we have set out what we see as important challenges to the validity -- internal,
38 external, and of other forms -- of social research in energy associated with the COVID-19
39 pandemic and measures put in place to control it. We have suggested a number of principles
40 we think researchers should consider applying to give themselves and the users of their
41 work confidence that the findings and recommendations they present will still be valid in the
42 years to come. These focus mainly on the collecting and reporting of additional contextual
43 data, and the review of research design elements to ensure they are as robust as possible to
44 pandemic-related impacts.

45
46
47
48 We think that these principles can be employed with relatively minimal impact on resources
49 and timescales required for research. They even present some opportunities both to enrich
50 insight into social aspects of energy, and draw attention to measures to improve research
51 transparency that are still as-yet under-used in the energy field. However, we also need to
52 be mindful that due to limits on the kind of research approaches that can be employed during
53 the pandemic, there are likely to be important gaps in the knowledge generated during this
54 period. We all hope that the period of direct applicability of this paper will be as short as
55 possible, and that measures to control the spread of COVID-19 will soon no longer be
56 needed. Nonetheless, we also think that the considerations we raise here have enduring
57 relevance for energy social science in general, and the potential to contribute to more
58
59
60
61
62
63
64
65

widespread use of transparent, contextually aware and valid research practices in the long-term.

Acknowledgements

[Blinded for peer review] The authors declare no competing interests.

Author contributions

[Blinded for peer review]

Appendix

Table 2: Checklist of items to report or consider reporting in relation to COVID-19 pandemic validity challenges.

Checklist item	Section	Example
Report:		
Main details of COVID-19 response measures in action at the time/place of data collection, at least including: level of freedom to move around in public; degree to which schools and businesses are open.	Methods	“At the time of data collection, public movement in the UK was severely restricted by government measures to combat the COVID-19 pandemic. People were instructed to stay at home at all times, except for doing essential shopping, one period of daily exercise, working outside the home if work at home was impossible, and providing support to vulnerable people. All schools, hospitality venues and non-essential shops were closed.”
Consider reporting:		
How COVID-19 restrictions are applying to individual participants.	Results	“In our sample, 65% of participants reported staying at home at all times except for when conducting essential shopping and exercise. A further 25% also reported leaving home to undertake work or volunteering. 10% of the sample reported staying at home at all times.”
Consider tailoring of the following aspects of the research:		
Research design	Methods	“In response to the rapidly changing circumstances connected with the response to the COVID-19 pandemic, we introduced a longitudinal element to our data collection. The survey was administered over two waves separated by two months, allowing us to check whether any of the key independent variables changed over this time, and whether this was associated with any change in the outcome.”
Sample	Methods	“We anticipated that childcare responsibilities could play a role in [variable of interest]. We therefore

		selected to draw our sample for [region A], where schools were open as normal.”
Data collected (see Table 1 for suggested dimensions)	Methods	“In addition to employment status, we also collected data on the extent to which those in employment were working from home.”
Consider possible implications for:		
Findings	Discussion	“We found a strong association between altruism and stated willingness to participate over both waves of the study. However, the association was weaker in the second wave, which, combined with the change in reported application of COVID-19 response measures (while other variables remained stable), suggests that conditions surrounding the COVID-19 pandemic could have affected this finding.”
Recommendations	Conclusion	“Our findings suggest that policymakers should prioritise energy saving messaging framed in terms of benefits to the local environment. However, our participants reported spending more time in their local area as a result of COVID-19 control measures which could have influenced our result. We therefore recommend that the effectiveness of such messaging be carefully monitored.”

References

- [1] W.R. Shadish, T.D. Cook, D.T. Campbell, *Experimental and quasi-experimental designs for generalized causal inference*/William R. Shadish, Thomas D. Cook, Donald T. Campbell., Boston: Houghton Mifflin, 2002.
- [2] S.O. Funtowicz, J.R. Ravetz, *Uncertainty, complexity and post-normal science*, *Environmental Toxicology and Chemistry: An International Journal*. 13 (1994) 1881–1885.
- [3] S. Healy, *Extended peer communities and the ascendance of post-normal politics*, *Futures*. 31 (1999) 655–669.
- [4] S. Sareen, H. Thomson, S.T. Herrero, J.P. Gouveia, I. Lippert, A. Lis, *European energy poverty metrics: Scales, prospects and limits*, *Global Transitions*. 2 (2020) 26–36.
- [5] M.K. Slack, J.R. Draugalis Jr, *Establishing the internal and external validity of experimental studies*, *American Journal of Health-System Pharmacy*. 58 (2001) 2173–2181. <https://doi.org/10.1093/ajhp/58.22.2173>.
- [6] J.W. Lucas, *Theory-Testing, Generalization, and the Problem of External Validity*, *Sociological Theory*. 21 (2003) 236–253. <https://doi.org/10.1111/1467-9558.00187>.
- [7] J. Qiu, B. Shen, M. Zhao, Z. Wang, B. Xie, Y. Xu, *A nationwide survey of psychological distress among Chinese people in the COVID-19 epidemic: implications and policy recommendations*, *General Psychiatry*. 33 (2020).
- [8] M. Ballew, P. Bergquist, M. Goldberg, A. Gustafson, J. Kotcher, J. Marlon, A. Roess, E. Maibach, A. Leiserowitz, *Americans’ Risk Perceptions and Emotional Responses to COVID-19 – April 2020*, Yale University and George Mason University. New Haven, CT: yale program on Climate Change Communication, 2020.
- [9] OECD, *Coronavirus (COVID-19) From pandemic to recovery: Local employment and*

- economic development, OECD, 2020. Retrieved from https://read.oecd-ilibrary.org/view/?ref=130_130810-m60ml0s4wf&title=From-pandemic-to-recovery-Local-employment-and-economic-development.
- [10] D.L. Rosenfeld, E. Balcetis, B. Bastian, E. Berkman, J. Bosson, T. Brannon, A.L. Burrow, D. Cameron, C. Serena, J.E. Cook, Conducting Social Psychological Research in the Wake of COVID-19, (2020). <https://doi.org/10.31234/osf.io/6gjfm>.
- [11] E. Thern, J. de Munter, T. Hemmingsson, F. Rasmussen, Long-term effects of youth unemployment on mental health: does an economic crisis make a difference?, *J Epidemiol Community Health*. 71 (2017) 344. <https://doi.org/10.1136/jech-2016-208012>.
- [12] IEA, Global Energy Review 2020, IEA, Paris, 2020. Retrieved from <https://www.iea.org/reports/global-energy-review-2020>.
- [13] C.J. Meinrenken, V. Modi, K.R. Mckeown, P.J. Culligan, New Data Suggest COVID-19 Is Shifting the Burden of Energy Costs to Households, (2020). Retrieved from <https://blogs.ei.columbia.edu/2020/04/21/covid-19-energy-costs-households/>.
- [14] B.K. Sovacool, J. Axsen, S. Sorrell, Promoting novelty, rigor, and style in energy social science: towards codes of practice for appropriate methods and research design, *Energy Research & Social Science*. 45 (2018) 12–42.
- [15] M.H. Goldberg, S. van der Linden, The Importance of Heterogeneity in Large-Scale Replications, *Journal of Social and Political Psychology*. 8 (2020) 25–29.
- [16] T. Hargreaves, L. Middlemiss, The importance of social relations in shaping energy demand, *Nature Energy*. (2020) 1–7.
- [17] P.W. Schultz, M. Estrada, J. Schmitt, R. Sokoloski, N. Silva-Send, Using in-home displays to provide smart meter feedback about household electricity consumption: A randomized control trial comparing kilowatts, cost, and social norms, *Energy*. 90 (2015) 351–358.
- [18] P. Mastropietro, P. Rodilla, C. Batlle, Measures to tackle the Covid-19 outbreak impact on energy poverty: Preliminary analysis based on the Italian and Spanish experiences, (2020). <https://fsr.eui.eu/measures-to-tackle-the-covid-19-outbreak-impact-on-energy-poverty/>.
- [19] M. Pareek, M.N. Bangash, N. Pareek, D. Pan, S. Sze, J.S. Minhas, W. Hanif, K. Khunti, Ethnicity and COVID-19: an urgent public health research priority, *The Lancet*. (2020).
- [20] M. Betrand, G. Briscece, M. Grignani, S. Nassar, How are americans coping with the Covid-19 crisis? 7 key findings from household survey, *Rustandy Center Blog*. (2020). <https://www.chicagobooth.edu/research/rustandy/blog/2020/how-are-americans-coping-with-the-covid19-crisis-7-key-findings>.
- [21] WHO Europe, Survey tool and guidance: behavioural insights on COVID-19, WHO, 2020.
- [22] J. Grandin, S. Sareen, What sticks? Ephemerality, permanence and local transition pathways, *Environmental Innovation and Societal Transitions*. 36 (2020) 72–82. <https://doi.org/10.1016/j.eist.2020.04.008>.
- [23] J. Pearl, *Causality*, Cambridge university press, 2009.
- [24] T.D. Cook, W.R. Shadish, V.C. Wong, Three conditions under which experiments and observational studies produce comparable causal estimates: New findings from within-study comparisons, *Journal of Policy Analysis and Management: The Journal of the Association for Public Policy Analysis and Management*. 27 (2008) 724–750.
- [25] W.R. Shadish, M.H. Clark, P.M. Steiner, Can nonrandomized experiments yield accurate answers? A randomized experiment comparing random and nonrandom assignments, *Journal of the American Statistical Association*. 103 (2008) 1334–1344.
- [26] Open Science Collaboration, Estimating the reproducibility of psychological science, *Science*. 349 (2015) aac4716.
- [27] R.A. Klein, M. Vianello, F. Hasselman, B.G. Adams, R.B. Adams Jr, S. Alper, M. Aveyard, J.R. Axt, M.T. Babalola, Š. Bahník, Many Labs 2: Investigating variation in replicability across samples and settings, *Advances in Methods and Practices in Psychological Science*. 1 (2018) 443–490.

- 1 [28] J.F. Landy, M.L. Jia, I.L. Ding, D. Viganola, W. Tierney, A. Dreber, M. Johannesson, T.
2 Pfeiffer, C.R. Ebersole, Q.F. Gronau, Crowdsourcing hypothesis tests: Making
3 transparent how design choices shape research results., *Psychological Bulletin*. (2020).
4 [29] E.L. Uhlmann, C.R. Ebersole, C.R. Chartier, T.M. Errington, M.C. Kidwell, C.K. Lai, R.J.
5 McCarthy, A. Riegelman, R. Silberzahn, B.A. Nosek, Scientific utopia III:
6 Crowdsourcing science, *Perspectives on Psychological Science*. 14 (2019) 711–733.
7 <https://doi.org/10.1177/1745691619850561>.
8 [30] M. Ienca, E. Vayena, On the responsible use of digital data to tackle the COVID-19
9 pandemic, *Nature Medicine*. 26 (2020) 463–464. [https://doi.org/10.1038/s41591-020-](https://doi.org/10.1038/s41591-020-0832-5)
10 [0832-5](https://doi.org/10.1038/s41591-020-0832-5).
11 [31] M. Goldberg, A. Gustafson, E. Maibach, M.T. Ballew, P. Bergquist, J. Kotcher, J.R.
12 Marlon, S. Rosenthal, A. Leiserowitz, Mask-wearing increases after a government
13 recommendation: A natural experiment in the US during the COVID-19 pandemic,
14 (2020). <https://doi.org/10.31234/osf.io/uc8nz>.
15 [32] D. Sui, J. Coleman, *Convergence Research in the Age of Big Data: Team Science,*
16 *Institutional Strategies, and Beyond*, Merrill Series on The Research Mission of Public
17 Universities. (2019) 23–35.
18 [33] G. Huebner, M. Fell, TReQ Tools: How to Improve Transparency, Reproducibility and
19 Quality in Energy Research, (2020). <https://doi.org/10.6084/m9.figshare.11663466.v1>.
20 [34] N.A. Worren, K. Moore, R. Elliott, When theories become tools: Toward a framework for
21 pragmatic validity, *Human Relations*. 55 (2002) 1227–1250.
22 <https://doi.org/10.1177/a028082>.
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65