![UKERC_2col_descriptor-[Converted]]()

**UKERC Technology and Policy Assessment**

**Systematic review of consumer attitudes towards voltage quality**

Scoping note

April 2015

Jamie Speirs

**The UK Energy Research Centre**

The UK Energy Research Centre (UKERC) carries out world-class research into sustainable future energy systems.

It is the hub of UK energy research and the gateway between the UK and the international energy research communities. Our interdisciplinary, whole systems research informs UK policy development and research strategy.

[www.ukerc.ac.uk](http://www.ukerc.ac.uk)

**The Technology and Policy Assessment (TPA) Theme of UKERC**

The Technology and Policy Assessment (TPA) was set up to inform decision-making processes and address key controversies in the energy field. It aims to provide authoritative and accessible reports that set very high standards for rigour and transparency. Subjects are chosen after extensive consultation with energy sector stakeholders and upon the recommendation of the TPA Advisory Group, which is comprised of independent experts from government, academia and the private sector.

The primary objective of the TPA is to provide a thorough review of the current state of knowledge. New research, such as modelling or primary data gathering may be carried out when essential. It also aims to explain its findings in a way that is accessible to non-technical readers and is useful to policymakers.

Contents

[**1. Voltage: Consumer attitudes and behaviour 4**](#_Toc416439290)

[**1.1. Research question 4**](#_Toc416439291)

[**2. Introduction to voltage regulations and consumer response to change 4**](#_Toc416439292)

[**2.1. Technical review 5**](#_Toc416439293)

[**2.2. Public attitudes 6**](#_Toc416439294)

[**3. The review of evidence 6**](#_Toc416439295)

[**3.1. Rapid Evidence Assessment (REA) 6**](#_Toc416439296)

[**3.2. Establish the research question 7**](#_Toc416439297)

[**3.3. Review protocol 7**](#_Toc416439298)

[**Sources of evidence 7**](#_Toc416439299)

[**Search terms 7**](#_Toc416439300)

[**Categorisation 8**](#_Toc416439301)

[**3.4. Evaluate evidence and communicate findings 8**](#_Toc416439302)

[**4. References 8**](#_Toc416439303)

# Voltage: Consumer attitudes and behaviour

The ‘Transforming the Top and Tail’ project is an EPSRC Grand Challenge focussing on the changes needed in the physical infrastructure of UK electricity networks in order to achieve the UK’s 2050 decarbonisation targets. As part of this programme of work the consortium has investigated the potential to reduce the costs of distribution network upgrades by relaxing UK voltage quality regulations. The implications of such a change for consumer electronics is explored by Frost and Mitcheson ([2013](#_ENREF_5)), outlining a number of effects on electronics that consumers might experience due to wider variation of supplied voltage.

While relaxing UK voltage regulations and varying UK voltage to consumers over a wider range is feasible from an engineering perspective, it is possible that consumers may experience increased failure or malfunction of electronic devices. Given this potential it is unclear whether consumers will accept change to UK voltage regulations.

In order to understand likely consumer responses to change in domestic voltage quality it may help to explore the available evidence on public attitudes to voltage quality, and other aspects of changing electricity provision. This scoping note sets out the details of a review of the available evidence on public attitudes towards changes in electricity supply.

This project is co-funded by the EPSRC projects UK Energy Research Centre and Transforming the Top and Tail.

## Research question

The project will examine the question:

To what extent does the existing evidence support the premise that consumers will accept change to domestic voltage regulations?

Assessing this question will include examination of a number of sub questions:

* Does the existing literature investigate consumer’s attitudes to or understanding of voltage in the domestic setting?
* Is there a wider literature on public attitudes to energy supply in general that is analogous to the question of voltage quality?
* Does this evidence highlight interesting aspects of public attitudes and understanding that can be informative to an assessment of consumer acceptance of changes to domestic voltage regulations?

# Introduction to voltage regulations and consumer response to change

The UK and European electricity regulations were harmonised in 1995, and UK legislation currently requires suppliers to deliver electricity to consumers in the range from 216.2 to 253 volts (230V +10%-6%). This is laid out in Part VII section 27 of The Electricity Safety, Quality and Continuity Regulations 2002 No 2665. Different events in the generation, transmission and distribution of electricity can cause variation in the voltage actually received by consumers. Power historically flowed in one direction down the low voltage distribution network to consumers, and voltage variations were typically undervoltages (voltage dropping below nominal). As a result Distribution Network Operators (DNOs) typically set their transformers at the upper end of the range allowed under voltage regulations, allowing dips in voltage to remain within permissible limits ([Seljeseth *et al.* 2009](#_ENREF_9)). However, distributed generation (DG), and the increases in load due to electric vehicles (EVs) and electric heat pumps (HPs) have changed the nature of voltage variations ([Kelly *et al.* 2012](#_ENREF_8)). If, as is frequently the case, high levels of DG correspond with low levels of base load ([Gonzalez *et al.* 2012](#_ENREF_6)), voltage rise can occur, and if voltage is maintained near the upper end of the permissible range it can exceed this range very quickly ([Frost & Mitcheson 2013](#_ENREF_5)). Managing this problem can have a number of undesirable outcomes, including automatic curtailment of renewable DG ([Frost & Mitcheson 2013](#_ENREF_5)).

## Technical review

Given the recent changes in voltage trends there is increased interest in finding new solutions to voltage regulation that can accommodate the low carbon transition. One option being examined is the relaxation of the regulations limiting voltage variation. This could potentially increase the capacity and level of DG that can be accommodated by the network, without significant network upgrades and associated costs. However, such an action may have a significant impact on the appliances connected to the electricity network.

Frost and Mitcheson ([Frost & Mitcheson 2013](#_ENREF_5)) examined the effect of widening the UKs voltage regulations on consumer electronic appliances as part of the Top and Tail project. Their report first identified four groups of appliances that may be affected by wider voltage variation:

* Lighting
* Heating
* Motors
* Electronic equipment (e.g. TVs, PCs, media devices)

The report then describes simulation experiments to determine how much wider voltage variation could be before the thermal limits of the distribution network cables is reached. The report recommends that, if significant DG is present on the distribution network then capacity of the network could be significantly increased without cable upgrades by setting the transformer to slightly above nominal voltage, at 235V, and that voltage variation should be allowed between 12%-15% below 230V and 10% above 230V.

The report then tests and simulates the impact on consumer electronics of varying voltage outside the current regulated range. The report also examines studies in the literature that conduct similar analyses. On this basis the authors suggest that over 98% of UK domestic appliance loads will continue to operate correctly at voltages within the new proposed minimum voltage of 15% below 230V.

While this finding suggests that the impacts on consumer electronics of a widened range of voltage variability will be extremely limited, it is not a guarantee of zero impact. Understanding the likely public attitude to this finding is important before pursuing this as a solution to increasing distribution network capacity at least cost.

## Public attitudes

Understanding the likely public attitudes to changes in voltage regulation may be key to facilitating the kinds of changes investigated by [Frost and Mitcheson (2013](#_ENREF_5)). There is evidence to suggest that often electricity consumers have an imperfect understanding of the electricity system ([DEFRA 2007](#_ENREF_3)). This is against the backdrop of a wider literature documenting the limitations in public understanding of science in general ([Bauer 2009](#_ENREF_1)). There is also a recent history of public opposition in the UK to changes in the electricity system, including those arising from decarbonisation policy, with a growing literature examining aspects of this opposition ([Devine-Wright 2007](#_ENREF_4)).

From early findings there appears to be a paucity of literature on consumer’s attitudes to domestic electricity voltage and its regulation, despite the recent harmonisation of voltage across Europe. This lack of literature may be for a number of reasons. First, the impact of voltage harmonisation on UK electricity distribution and supply was very limited, and the way harmonisation was implemented in the UK may not have had a significant impact on consumers. Second, the perceived limitations of public engagement in electricity and voltage may have dissuaded research in this area.

Due to the lack of an evidence base it is necessary to examine a broader literature of relevant research that may inform an understanding of consumer attitudes and behaviour in the face of electricity system change. There is a growing literature focussing on the public awareness and understanding of forms of energy technology and their impacts. [Devine-Wright (2007](#_ENREF_4)) reviews a number of studies, summarising their findings and providing an analysis for the reasoning behind these public attitudes. The literature may yield other similar analyses in order to provide more evidence analogous to the issues facing electricity consumers with relaxed voltage tolerance.

# The review of evidence

The project team will draw on their expertise in systematic evidence review in energy policy to inform the development of a review protocol designed to unearth and review the relevant evidence on public attitudes to changes in the electricity system. The following describes the proposed aspects of this review.

## Rapid Evidence Assessment (REA)

The project team have extensive experience in conducting full systematic reviews in their work for the UK Energy Research Centre (UKERC)[[1]](#footnote-1). The team have recently begun to design a Rapid Evidence Assessment (REA) protocol, adapting similar methods from other policy arenas to the needs of energy policy ([Watt *et al.* 2008](#_ENREF_10); [Collins *et al.* 2014](#_ENREF_2)). In evidence review methods there is a trade-off between rapidity and rigour, and REA is a form of evidence review designed to deliver assessments more rapidly, while minimising the impact on rigour. REA is appropriate in this instance given the defined scope of the research question and relatively limited literature base apparent from early review findings.

As common to many evidence assessment methods, REA should consist of the following steps (adapted from ([GSR 2013](#_ENREF_7); [Collins *et al.* 2014](#_ENREF_2))):

* Establish the research question
	+ Establish an expert group
	+ Present a scoping note
	+ Refine based on expert feedback
* Conduct review
	+ Establish a review protocol
	+ Conduct searches
	+ Filter and categorise evidence
* Evaluate evidence and communicate findings
	+ Synthesise evidence
	+ Develop explanatory narrative
	+ Communicate findings

The following describes the proposed approach to each of these aspects of the review.

## Establish the research question

Establishing the research question includes the defining the scope of research, seeking expert comment, and revising all aspects of the research question accordingly. Here the research question was established as part of the Top & Tail research plan, and is further developed in this scoping note. An expert group, comprising members of the wider Top & Tail consortium will be engaged to provide comment on the research question, the scope of the review and other aspects of the research as they arise through the course of the review.

##  Review protocol

The following review protocol sets out the process through which evidence will be searched for, collected and categorised. This includes the sources of evidence (databases and search engines), the search terms to be used and the coding method used to organise the evidence into categories.

### Sources of evidence

The following of databases and search engines will be searched in order to uncover the evidence base. The limited number of sources reflects the nature of this review, though this coverage of the literature sources is expected to deliver excellent coverage of the available evidence.

Table : Evidence sources included in the review

|  |  |
| --- | --- |
| **Database** | **Aspect of literature covered** |
| Science direct | Peer-reviewed academic literature |
| Web of Science | Peer-reviewed academic literature |
| World Cat | Grey literature and library catalogues |
| Google (scholar and web) | Peer-review and grey literature |

### Search terms

The following matrix presents the proposed search terms, organised by themes. These search terms will be combined in appropriate Boolean strings based on the search engine requirements.

Table : Search terms

|  |  |  |  |
| --- | --- | --- | --- |
| **Consumer terms** | **Attitude terms** | **Electricity system terms** | **Consumer utility terms** |
| Consumer | Attitude  | Voltage | Quality |
| Public | Response | Network | Regulation |
| Customer | Acceptability | Distribution | Disruption |
|  | Willingness | Transmission | Tolerance |
|  | Participation | DNO |  |
|  | Object\* | Supply |  |
|  | Understand\* | Energy |  |
|  | Oppos\* |  |  |
|  |  |  |  |
|  |  |  |  |

### Categorisation

Evidence collected will be categorised to aid in analysis and synthesis. Potential categorisations are listed below but this will be refined based on priorities that emerge during evidence gathering.

* Type of electricity system change
* Methodology
	+ This could be focus group, survey, literature review.
* Number of participants
	+ If the evidence includes a focus groups or survey data then the sample size can be recorded
* Outcome
	+ Some qualitative notes can be gathered highlighting the findings of individual pieces of evidence.
* Geographical boundary
	+ UK, Europe, USA etc.

## Evaluate evidence and communicate findings

The evidence uncovered through this REA will be examined and used to highlight the consumer facing issues associated with changing voltage regulations. The findings of the project will be delivered in a synthesis report, and findings disseminated through Top & Tail and UKERC project meetings and presentations.

# References

Bauer, M. W. (2009). "The Evolution of Public Understanding of Science—Discourse and Comparative Evidence." Science Technology & Society **14**(2): 221-240.

Collins, A., J. Miller, D. Coughlin and S. Kirk (2014). The Production of Quick Scoping Reviews and Rapid Evidence Assessments: A How to Guide, Joint Water Evidence Group - Beta Version 2.

DEFRA (2007). Public Understanding of Sustainable Energy Consumption in the Home.

Devine-Wright, P. (2007). Reconsidering public attitudes and public acceptance of renewable energy technologies: a critical review.

Frost, T. and P. Mitcheson (2013). Impacts of wider voltage tolerances on consumer electronics and wider socialised costs. Report for : EP/I031707 - Transformation of the top and tail of energy networks. London, Imperial College London. EPSRC.

Gonzalez, C., J. Geuns, s. Weckx, T. Wijnhoven, P. Vingerhoets, T. De Rybel and J. Driesen (2012). LV distribution network feeders in Belgium and power quality issues due to increasing PV penetration levels. Innovative Smart Grid Technologies (ISGT Europe), 2012 3rd IEEE PES International Conference and Exhibition on.

GSR. (2013). "Rapid evidence assessment toolkit." Civil Service Retrieved 31st March 2014, from <http://www.civilservice.gov.uk/networks/gsr/resources-and-guidance>.

Kelly, N., P. Tuohy and M. Thomson. (2012). "Future Energy Demand in the DomesticSector " Retrieved 28th February 2015, from <http://www.topandtail.org.uk/publications/N.Kelly.WP2%201ReportFutureEnergyDemand.pdf>.

Seljeseth, H., K. Sand and K. E. Fossen (2009). Laboratory tests of electrical appliances immunity to voltage swells. Electricity Distribution - Part 2, 2009. CIRED 2009. The 20th International Conference and Exhibition on.

Watt, A., A. Cameron, L. Sturm, T. Lathlean, W. Babidge, S. Blamey, K. Facey, D. Hailey, I. Norderhaug and G. Maddern (2008). "Rapid reviews versus full systematic reviews: an inventory of current methods and practice in health technology assessment." International Journal of Technology Assessments in Healthcare **24**(2): 133-139.

1. <http://www.ukerc.ac.uk/programmes/technology-and-policy-assessment.html> [↑](#footnote-ref-1)