Energy Networks Association - Statutory Voltage Limits Consultation

About the IET

The IET is a trusted adviser of independent, impartial, evidence-based engineering and technology expertise. We are a registered charity and one of the world's leading professional societies for the engineering and technology community with over 158,000 members worldwide in 148 countries. Our strength is in working collaboratively with government, industry and academia to engineer solutions for our greatest societal challenges. We believe that professional guidance, especially in highly technological areas, is critical to good policy making. For further details on the evidence submitted, please contact policy@theiet.org

Introduction

Reducing the low-voltage (LV) statutory limit should form part of a coordinated, system-wide voltage management strategy rather than a standalone measure. The IET recommends the following:

- **Pragmatic actions**: Prioritise measures to prevent customer voltages exceeding the upper statutory limit and causing nuisance inverter trips. Low voltage (LV) system voltages should be brought closer to appliance design ratings (220–240 V).
- **Improved visibility**: Enhance real-time or regular time-series monitoring of voltage profiles at LV and higher voltages. This is increasingly important given the growth of rooftop PV and load-building technologies such as heat pumps and EV chargers, particularly in light of ambitions to significantly expand domestic solar capacity.
- **Avoid unintended system impacts**: Actions at higher-voltage substations to reduce LV must not compromise Grid Code compliance, including OC6.5.3 requirements for staged voltage reduction. Transformers operating close to bottom tap may have limited headroom to deliver required reductions.
- **Whole-system modelling and monitoring**: The impacts of an increasingly inverter-based resource (IBR) system must be studied and monitored to ensure voltage stability, frequency resilience and protection performance are maintained.

Current network voltages are generally biased towards the upper end of the permitted range. A structured programme of voltage reduction should be developed to rebalance operating levels while maintaining operability under OC6. Much of this could progress within existing statutory limits. However, setting an appropriate statutory minimum voltage now would provide a clear design envelope for future systems and increase headroom between minimum and maximum conditions, supporting further low-carbon technology adoption with minimal risk to customers. Consideration should also be given to customer installations designed under the IET Wiring Regulations, where phased implementation of any revised standard may be appropriate.

From a technical perspective, several factors require consideration:

- **Protection performance**: Voltage is a factor in short-circuit calculations (e.g. IEC 60909), and earth loop impedance calculations in line with the IET Wiring Regulations (BS7671). Lower operating voltages may reduce prospective fault current and marginally extend clearance times, although this may be offset by embedded generation infeed.

- **Fault levels and transmission interactions**: Declining short-circuit levels are primarily a transmission issue as synchronous machines with inverter based resources are displaced. At LV, transformer impedance dominates, so impacts are typically less pronounced.
- **Embedded generation and holistic considerations**: Batteries and rooftop PV may increase maximum fault levels due to additional infeed during faults.
- **Inverter-based resource behaviour**: LV-connected inverters generally contribute fault current limited to their rating for short transient durations.
- **Low inertia and stability**: Reduced inertia is mainly a transmission concern but can interact with distributed generation ride-through behaviour and voltage stability. Loss of load under conditions of high voltages and low load can create additional system risks, so we consider that the current bias towards high voltages should be more concerning than low voltages.

Overall, future LV networks may experience a broader range of system conditions, with both more generation and lower loads or higher continuous loading at different times of year. The changes expected with the increased adoption of low carbon technologies underlines the need for voltage limit changes to be implemented within a holistic, forward-looking system design framework.

Questions

1. *In principle, do you support the proposed change to the statutory voltage limits? Please provide details*

Yes, The IET supports consideration of a reduction in the lower statutory voltage limit. However, this support is conditional upon the change forming part of a wider, system-level voltage management strategy, rather than being implemented as a standalone regulatory adjustment.

Evidence indicates that the UK low-voltage (LV) system already operates consistently towards the upper end of the statutory range. Smart meter data shows that average LV voltages experienced by customers are approximately 243V, despite a nominal system voltage of 230V. The LV winding of a standard MV/LV three-phase transformer has a nominal output of 433V when supplied at rated high voltage (e.g. 11 kV or 6.6 kV). The LV system was originally designed to provide a nominal supply voltage to customers of 415V three-phase and 240V single-phase.

Digital sensor data and information from smart EV chargers demonstrate numerous examples of statutory voltage limits being exceeded, particularly during summer periods characterised by low demand and high distributed generation. This reflects historic network design assumptions, transformer winding ratios and tap position ranges that were appropriate for a largely passive, demand-led system, but which are increasingly misaligned with today’s more dynamic and bidirectional networks.

The rapid growth of solar generation, electric vehicles and power electronic technologies means that current operating practices are increasingly out of step with modern system requirements. Total UK solar capacity is expected to reach 45 - 47 GW by 2030, with the potential to exceed 85 GW by 2035. Rooftop solar ambitions of around 20 GW by 2030, split roughly equally between residential and commercial installations under the UK Solar

Roadmap, are significant. In addition, the Warm Homes Plan targets a threefold increase in residential rooftop solar by 2040, which could amount to approximately 18 GW of residential capacity alone by 2030. At the same time, electric vehicle charging infrastructure is expanding rapidly.

Elevated system voltage is already having tangible impacts on both the system and consumers. Sample data suggests that up to 20% of EV chargers may be experiencing sustained over-statutory voltage, leading to charging interruptions. The IET is also aware of widespread examples of G98 solar PV inverters tripping above 253V, often due to local export-driven voltage rise or short-duration voltage spikes (sometimes less than 0.5 seconds). This results in lost renewable generation and consumer frustration. Breaches of statutory voltage limits represent statutory non-compliance and must be addressed.

Reducing the lower statutory voltage limit could enable a managed reduction in LV system voltage, thereby creating additional headroom to accommodate voltage rise from distributed generation. This may reduce unnecessary inverter disconnections and EV charger trips, and support wider deployment of low-carbon technologies, including load-building technologies such as heat pumps and EV chargers, which can reduce the need for network reinforcement.

Lowering system voltage could also help unlock the benefits of Conservation Voltage Reduction (CVR), which have already been demonstrated in trials. However, the IET does not consider a change to statutory voltage limits to be a silver bullet. Adjusting the LV statutory limits alone will not resolve broader issues relating to coordination, visibility and control capability across the electricity system.

Key challenges that remain include:

- System-wide coordination across LV, MV, HV and transmission networks.
- Visibility of distributed generation and behind-the-meter assets.
- Control capability and orchestration of large numbers of inverter-based resources.
- The evolving system physics associated with a low-inertia, low short-circuit-level, inverter-dominated network.

Accordingly, any change to the statutory voltage limits must be accompanied by:

- Appropriate safeguards and consumer protections.
- Robust monitoring and data transparency.
- Clear alignment with a broader voltage management roadmap, including actions deliverable within existing statutory limits.

Government should also consider concerns relating to fault clearance times and assurance, given the potential reduction in prospective short-circuit current associated with lowering LV system voltage, including impacts beyond the meter. It is notable that the original lower limit of ‘240V −6%’ equated to 226V; consideration is now being given to lowering this limit to 207V. The implications of such a change for protection performance and safety must be carefully assessed.

The IET supports consideration of a reduction in the lower statutory voltage limit, provided it is implemented as part of a coordinated, system-wide voltage management strategy with appropriate safeguards and technical assurance.

2. *Do you agree with the potential benefits and challenges of reducing the lower statutory voltage limits detailed in this paper and the supporting evidence paper? Please provide details*

The IET broadly agrees with both the potential benefits and the challenges identified in the paper and considers them to be supported by the available evidence. The potential benefits are material and strategically aligned with decarbonisation and network efficiency objectives. However, the challenges we have identified are real and, in many cases, systemic in nature. Addressing them will require coordinated action across policy, regulation, network operation and standards, supported by robust evidence and whole-system analysis.

Benefits

Mitigation of voltage rise in high PV penetration areas: Allowing lower minimum supply voltages may allow set points to be changes and offer greater flexibility to accommodate higher amounts of solar PV within upper statutory voltages. With the increasing adoption of solar generation, storage and low carbon technologies, the difference between maximum and minimum load (or even net export) is likely to increase. Allowing more freedom for engineers in designing the system may result in a lower cost system for consumers.

Improved utilisation of distributed generation: Reducing baseline LV voltage would improve the utilisation of distributed generation by reducing unnecessary curtailment and inverter disconnections. This would enable more effective use of clean energy and improve customer experience.

System-wide energy savings through Conservation Voltage Reduction (CVR): CVR trials indicate energy savings in the range of 1–1.2% for every 1% reduction in voltage. This has been estimated to equate to approximately £56 per household per year, around £1.5 billion per year across Great Britain, and potentially £19 billion cumulatively by 2050.

It is reasonable to assume that electrical appliance manufacturers design products to operate most efficiently at 230V (or within the commonly labelled range of 220–240V). While further apparent energy savings may sometimes arise from operating below 220V, this may be achieved at the expense of output performance or service quality, which customers may or may not notice.

Peak demand reduction: CVR studies indicate potential peak demand reductions of up to 2.7 GW across Great Britain. This could help avoid or defer significant future investment in generation and network reinforcement.

Increased network hosting capacity: Evidence suggests that monitoring alone can deliver approximately a 22% increase in network hosting capacity. Monitoring combined with active voltage control indicates the potential for up to 50% additional capacity for EVs and solar PV. These gains are material and align strongly with Clean Power 2030 (CP2030) targets, the UK Solar Roadmap and wider decarbonisation objectives.

Challenges

Interaction with Automatic Voltage Control and tap changer limits: Potential interactions with higher-voltage Automatic Voltage Control (AVC) schemes and transformer tap limits must be carefully considered. Emerging evidence indicates that some primary substations are already operating close to minimum tap positions, limiting downward voltage headroom. Many are within four taps of the bottom tap position under light load conditions (with typical tap intervals of 1.25%).

At the distribution level, many transformers are operating one tap above the bottom tap position, which delivers the lowest voltage output, leaving only approximately 2.5% scope for further reduction by this means. Adjusting taps at scale would in most cases require at least a short planned outage and would be highly resource-intensive, given that there are several hundred thousand distribution transformers across the UK.

It is pivotal to consider the implications of Grid Code OC6. For example, transformers operating fewer than four taps above bottom tap may be unable to deliver the two voltage reduction stages of between 2% and 4% required under Grid Code OC6.5.3. DNOs could meet OC6 requirements through DSR, controlled load shedding, or CVR on portions of the network with remaining headroom. This could constrain system operability under certain transmission-level contingencies. However, they need to be applied rapidly and uniformly across the system to deliver up to 3% demand reduction. One option for DNOs is on instruction from NESO to lock taps at all primary substations and switch out one of two (or more) transformers at each site. Very rapid (mainly a frequency response method) but the CLASS project demonstrated this can give an instantaneous voltage reduction of up to around 1.5%.

Appliance performance and longevity: There remains uncertainty regarding the long-term impacts of sustained lower voltages on certain types of equipment, particularly electric motors, where potential risks include overheating, reduced torque and shortened lifespan. While appliance compatibility is not considered a fundamental barrier — as EU-certified appliances must operate correctly within 207–253V, and EV charger standards are aligned to 208V — performance characteristics may change at lower voltages.

For example, a resistive storage heater will draw approximately 19% less power for a 10% reduction in voltage. However, it will still require the same total energy input to achieve a given level of stored heat. In exceptionally cold weather, a reduced charging rate could result in failure to achieve a full overnight charge, potentially affecting comfort levels.

Lower Prospective Short-Circuit Current (PSCC) issue: Government must be weary regarding fault clearance times and assurance, given the potential reduction in PSCC associated with lowering LV system voltage, including impacts beyond the meter. We have explored this challenge further in our answer to question 3.

System-level complexity and modelling requirements
A clear need exists for improved data, coordination and whole-system modelling to avoid unintended consequences. Many of the identified challenges arise from interactions across voltage levels and between transmission and distribution networks, rather than purely local distribution effects. As such, any change must be assessed within a comprehensive system context.

3. *Do you support the proposed phased implementation proposed by the network operators to implement the lower voltage limit across the network gradually over two years, undertaking a review of any impacts as the limit is adjusted? Please provide details*

The IET supports a phased and carefully monitored implementation, subject to robust review points and clearly defined success and exit criteria with realistic expectations for DNO’s. A phased implementation can work provided that it is underpinned by rigorous monitoring, transparent reporting and predefined criteria for progression, adjustment or pause.

A two-year phased approach would allow Government and network operators to observe real-world impacts, identify regional, seasonal or asset-specific sensitivities, and ensure that learning is fed back into operational practices. This should not be regarded solely as a risk-mitigation step, but as an opportunity to build an evidence base to inform future voltage management policy and standards development.

To maximise the value of the proposed reviews, they must be evidence-based, transparent and shared openly across the sector. Reviews should be informed by detailed data on:

- Voltage profiles and excursions across voltage levels.
- Protection performance and fault clearance behaviour.
- Inverter response characteristics, including nuisance tripping.
- Automatic Voltage Control (AVC) headroom and tap utilisation.

Monitoring should extend beyond network operation alone. It should also encompass:

- Customer complaints and reported appliance performance issues.
- Protection margins and fault behaviour, including prospective short-circuit current.
- Inverter performance, including interactions with AVC schemes across voltage levels.

If a statutory range of 230V ±10% is adopted (i.e. 207–253V), the upper limit would sit very close to the threshold at which inverter trips (for solar PV and EV chargers) are likely to occur. It would therefore be prudent to define tighter operational planning limits to provide an appropriate safety margin — for example, operating within approximately 230V ±20V — in order to reduce the risk of avoidable disconnections while remaining compliant with statutory requirements.

4. *Are you aware of any potential benefits or challenges related to reducing the statutory voltage limits that are not detailed in this paper and the supporting evidence paper? Please provide details*

There are several additional system-level considerations that merit attention beyond those outlined in the consultation paper and supporting evidence. These considerations relate to low-inertia and low short-circuit-level interactions, design basis and standards gaps, visibility and coordination limitations, and skills and interdisciplinary challenges.

Low-inertia and low short-circuit-level interactions: Lower operating voltages could, in some circumstances, compound declining fault levels in inverter-dominated systems. When combined with reduced system inertia, this may erode protection margins and challenge critical fault-clearance times, particularly on overhead-line-dominated transmission networks. Operating a low-inertia system at the upper end of the voltage range can further increase instability by conflating voltage and security risks.

However, low inertia is not a prerequisite for system risk. A widespread overvoltage condition can trip embedded and distributed generation at scale, potentially exceeding a credible security contingency (for example ~1.8 GW). The sudden loss of distributed generation can appear operationally as a rapid increase in demand rather than a loss of central generation, increasing the risk of low-frequency demand disconnection (LFDD) and, in extreme cases, system collapse. Pre-fault voltage suppression on distribution transformers may also create challenging dynamics, with voltages transitioning rapidly from high to low and limited time for tap-changer response, potentially contributing to voltage instability. These distribution-level dynamics merit closer examination in system disturbance analysis.

The interaction described above is most relevant where voltage reduction extends to higher voltage levels; statutory limits above LV and below 132 kV remain at ±6%. At LV, fault levels are predominantly determined by local transformer characteristics and LV circuit impedance rather than upstream system fault levels. Consequently, reducing LV voltage alone is expected to have limited direct impact on fault levels.

Nevertheless, a reduction of approximately 19 V in the lower statutory limit compared with pre-harmonisation limits (240 V ±6%) would result in a corresponding reduction in LV prospective short-circuit current (PSSC). The principal concern is the potential impact on fault clearance performance. In particular, the minimum earth fault loop impedance values specified in **BS 7671** should be reviewed to ensure adequate protection performance and disconnection times are maintained for customers' electrical installations.

Design basis and standards gap: Voltage management changes should not be pursued in isolation from the development of a validated design basis for future inverter-dominated systems. A coherent framework is required to ensure alignment between statutory limits, protection coordination, operational security, and system resilience.

Visibility and coordination limitations: While smart meters, EV charge points and inverters generate valuable voltage and operational data, access is often limited, and delayed. Without improved real-time visibility and cross-network coordination, latent system risks may remain undetected until stressed conditions arise. Enhanced visibility and data sharing are essential to support safe and effective voltage management.

Skills and interdisciplinary challenges: Voltage management increasingly spans power electronics, protection engineering, control systems, communications, data analytics and regulatory policy. Siloed expertise risks obscuring critical system interactions. A coordinated, interdisciplinary approach is essential to ensure that statutory voltage limit adjustments are implemented safely and effectively.

5. *<u>What action would you expect to be taken (and from whom) for customers observing issues potentially caused by the operation of the electricity network at the lower statutory voltage? Please provide details</u>*

There needs to be a clear, coordinated, whole-system response framework, coupled with transparent communication with consumers, will be essential to maintaining trust and confidence during the implementation of lower statutory voltage limits. The responsibilities of different parties should be clearly defined and aligned.

Distribution Network Operators (DNOs)

- Act as the primary point of contact for customers experiencing voltage-related issues.
- Investigate, monitor, and remediate network-related causes where identified.
- Utilise proportional operational tools, including seasonal optimisation of Automatic Voltage Control (AVC) settings, tap changer adjustments, Active Network Management, and smart inverter or flexibility-based solutions.

Ofgem

- Ensure that consumer protections remain robust throughout the transition.
- Provide clarity on responsibilities, cost recovery mechanisms, and incentives for proactive voltage management.

Manufacturers and standards bodies

- Confirm appliance and equipment performance across the statutory voltage range.
- Feed operational evidence into the development of future product and connection standards.

Industry bodies, including the IET

- Provide independent technical scrutiny.
- Facilitate evidence gathering, knowledge sharing, and cross-sector collaboration.

6. *Do you have any questions that are not answered in this consultation nor the supporting technical report?*

From the IET's perspective, key unanswered questions include:

1. What is the long-term design basis for a Great Britain electricity system with minimal synchronous generation, and how does voltage management fit within that framework?
2. What independent, cross-disciplinary assurance exists that system-level risks are being adequately identified, modelled and mitigated?
3. How will visibility of distributed generation and inverter behaviour be improved to support more dynamic and coordinated voltage control?
4. What governance arrangements are required to ensure effective coordination across distribution, transmission, system operation, standards and policy?

Addressing these questions is essential to ensuring that voltage management strengthens rather than undermines the resilience and security of a future net-zero electricity system.