Public

Workgroup Consultation

GC0168: Submission of Electro Magnetic Transient (EMT) Models

Overview: As Great Britain's (GB) power system moves towards net zero carbon operation; the number of Plants connected by Electronic Power Converters (EPC) is expected to increase and the amount of synchronous generation on the grid to decline which will significantly change the characteristics of the GB network. These changes give rise to the potential control interactions between the devices across the network leading to increased risks of oscillations and inverter stability. This modification seeks to require certain Users to provide the National Energy System Operator (NESO) with Electromagnetic Transient (EMT) models to enable the analysis of issues such as system oscillations, inverter stability and Transient Over Voltage (ToV).

Modification process & timetable

1. **Proposal Form**
   05 March 2024
2. **Workgroup Consultation**
   23 January 2025 - 21 February 2025
3. **Workgroup Report**
   22 May 2025
4. **Code Administrator Consultation**
   04 June 2025 - 04 July 2025
5. **Draft Modification Report**
   24 July 2025
6. **Final Modification Report**
   07 August 2025
7. **Implementation**
   10 business days after implementation

Have 20 minutes? Read our Executive summary
Have 40 minutes? Read the full Workgroup Consultation
Have 120 minutes? Read the full Workgroup Consultation and Annexes.

Status summary: The Workgroup are seeking your views on the work completed to date to form the final solution(s) to the issue raised.

This modification is expected to have a: High impact Generators (including both GB Generators and EU Generators), NESO, Distribution Network Operators, Interconnector Owners, Transmission Owners and Non-Embedded Customers

Modification drivers: Efficiency, GB Compliance, Harmonisation, New Technologies, System Operability, System Planning, System Security, Transparency

Governance route	Standard Governance modification with assessment by a Workgroup	
Who can I talk to about the change?	**Proposer:** Frank Kasibante (NESO) frank.kasibante1@nationalenergyso.com 07812 774066	**Code Administrator Chair**: Sarah. Williams Sarah.williams@nationalenergyso.com 07593 899145
How do I respond?	Send your response proforma to Grid.Code@nationalenergyso.com **by 5pm on 21 February 2025**	

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Executive summary

This modification seeks to require certain Users to provide the NESO with EMT models to enable analysis of issues such as system oscillations, inverter stability and Transient Over Voltage (ToV) on the Transmission System.

What is the issue?

As Great Britain's power system moves towards net zero carbon operation, the network is transitioning from large synchronous generators to a large number of plants connected by Electronic Power Converters (EPC) which are causing new and varying challenges to the power system, for example control interactions, low fault level, inverter instability, ToV, etc. NESO requires Electromagnetic Transient (EMT) models from Users so that it can analyse and understand how these interactions affect the network under different system conditions. For some European code users, the demonstration of compliance requires such models to be used within the compliance process. For users subject to the modifications under Grid Code 141, the requirements for EMT model provision and the processes surrounding their provision have been clearly articulated. However, for GB Code User and early EU Code Users (prior to implementation of GC0141) not in these categories there is currently no clarity over how these models may be made available. The requirements in the current Grid Code for these relevant legacy users require Root Mean Square (RMS) models which are insufficient to accurately model the Transmission System with high proportions of EPC. This situation arises through the complex switching sequences that EPC s introduce, therefore requiring a detailed three phase representation through an EMT model rather than a positive phase sequence representation which is only available from an RMS model. Therefore, to accurately represent the behavioural characteristics of the Transmission System, detailed EMT models will be required.

Grid Code modification GC0141 (as approved by The Authority on 12 December 2022) already requires Users which either connected to the System on or after 1 September 2022 or were subject to a control system change or a Modification to already supply an EMT model. In addition, Grid Code Modification GC0102 (EU Connection Codes GB Implementation Mod 3) also enabled the NESO (formerly the ESO) to request an EMT Model from EU Code Users where required. However, this modification (GC0168) is now seeking the NESO to require relevant legacy Users (which do not fall under the requirements of GC0141 or GC0102) to provide an EMT model on a retrospective basis where such a model is required.

What is the solution and when will it come into effect?

Proposer's solution: The proposed solution is to mandate the collection of the EMT models from certain relevant legacy Users. A list of types of Users who will be affected by this obligation can be found in **Annex 4**. This will require updates to clauses in PC.3.3, PC.A.5, PC.A.6 and PC.A.9 as an amendment to the Annex of the General Conditions (referenced in GC 11) to introduce a new Electrical Standard which will indicate a step-by-step approach of collecting Electromagnetic Transient Models (EMT) from Users connected before 1st September 2022. These models will feed into a wider GB Model enabling investigations, post fault studies and planning studies. This will help to enable safe, reliable and economic operation of the system and enhance the security of GB electricity supply.

Implementation date: 10 working days after Ofgem Decision

Summary of potential alternative solution(s) and implementation date(s):

Currently no alternative solutions have been proposed.

What is the impact if this change is made?

High impact: Generators (including both GB Generators and EU Generators), NESO, Distribution Network Operators, Interconnector Owners, Transmission Owners and Non-Embedded Customers

Interactions

CUSC Modification may be raised relating to cost recovery.

Corresponding STC modification CM097 – Electromagnetic Transient (EMT) and Root Mean Square (RMS) Model Submission for Transmission Owners (TOs)

A separate modification will be established to introduce a new STCP.

What is the issue?

Great Britain's power system is moving towards net zero carbon operation.

The network transition from large synchronous generators to a large number of smaller EPCs is causing new and varying challenges to the power system, especially in view of the different operating and performance characteristics of EPC s when compared to their synchronous generator counter parts. Examples of these challenges include, control interactions, low fault level, inverter instability, transient overvoltage, etc, whose power electronics interact with the network in a different way to the older generators.

(NESO requires EMT models for Users so that it can analyse and understand how these interactions affect the network under different system conditions.

Why change?

Unlike a system with a previously high penetration of synchronous generation which could be adequately analysed and studied with Root Mean Square (RMS) models, an evolving system with a high penetration of EPC requires more detailed EMT models to perform investigations and analysis. This is largely as a result of the complex switching arrangements that take place in EPC s unlike their synchronous counterparts.

The current requirements in the Grid Code are insufficient to cover the User data that NESO requires. As noted above, EMT models from Users) are becoming essential to ensure that NESO can accurately model the Transmission System. Without these models, it restricts the ability of NESO to perform accurate system studies, modelling and post fault analysis.

What is the solution?

Proposer's solution

The proposed solution is to mandate the collection of the EMT models from all relevant Users where this data is required. This will require updates to clauses in the Grid Code Planning Code (PC.3.3, PC.A.5, PC.A.6 and PC.A.9) and the Grid Code General Conditions (Annex to the General Conditions (referenced in GC 11). As part of this modification, it is also proposed to develop a GB wide Electrical Standard which will provide guidance on a step-by-step approach on collecting EMT models from Users connected before September 2022 and EMT modelling guidelines.

These models will feed into a wider GB Model enabling investigations in the near term, in addition to post fault studies and planning studies. This will enable safe and reliable operation of the system and enhance the security of the GB Transmission System.

Workgroup considerations

The Workgroup convened 5 times to discuss the perceived issue, detail the scope of the proposed defect, devise potential solutions and assess the proposal in terms of the Applicable Code Objectives.

Consideration of the proposer's solution

PC.A.5.3, PC.A.5.4, PC.A.6 and PC.A.9

During Workgroup discussions, members highlighted areas of the legal text that either needed clarification or to be changed. The Proposer agreed to amend the necessary legal text and share with Workgroup members for review.

Model Collection Process PC.A.9.7.3

Workgroup members raised concerns regarding the 3-month timescale for sending validation reports to NESO in relation to model simulation results against measurements, members agreed that more time was needed. The Proposer agreed to amend the text to state the 3 months would start after compliance testing had been completed.

Cost of Model development and Cost Recovery

The Proposer noted that the Grid Code Review Panel (GCRP) had advised GC0168 Workgroup members to discuss and consider if a cost recovery mechanism was needed during their Workgroups. This had also been added into the Terms of Reference. Members agreed that there should be a cost recovery mechanism, but it was difficult to quantify as it would depend on the size of the unit, its age, type and if the manufacturer was still supplying equipment.

A NESO representative highlighted the cost recovery would apply to historical sites only and going forward this would be less of an issue as new sites would not be eligible to claim.

Additional Term of Reference (ToR)

It was suggested an additional item was added to the Terms of Reference by a NESO representative relating to the need to reflect international best practice. They suggested that the recent consultations relating to RfG 2.0 (EU Requirements for Generators 2.0) and HVDC 2.0 (High Voltage Direct Current 2.0) would provide an appropriate benchmark which was agreed by the Workgroup. ToR (l) was approved by the October Grid Code Review Panel and the Terms of Reference were amended to show the new reference.

Terms of Reference discussion

The Terms of Reference were reviewed during Workgroup 4 to ensure all key points had been considered.

a) Implementation and costs.

One member noted that when Panel members agreed the Terms of Reference for the Workgroup, they were not aware of what the outcome would be.

Discussions have taken place, and members are agreed that there is a need for a cost recovery mechanism which is likely to be implemented through a CUSC modification. As funding is a commercial issue that technically falls outside the Grid Code the issue would need to be addressed

through a CUSC modification. That said, there are a number of ways in which the CUSC Panel and indeed a CUSC Workgroup consider the most appropriate cost recovery mechanism, especially noting that some parties affected by this change, for example Licence Exempt Embedded Medium Power Stations (LEEMPS)) are not CUSC Parties.

b) Review draft legal text.

The legal text has been discussed thoroughly by Workgroup members and all comments and amendments have been considered by the Proposer. Work is ongoing to ensure the legal text is as robust as possible.

c) Consider whether any further Industry experts or stakeholders should be invited to participate within the Workgroup to ensure that all potentially affected stakeholders have the opportunity to be represented in the Workgroup. Demonstrate what has been done to cover this clearly in the report; and

Two sets of nomination requests were issued to industry to encourage stakeholders to register for GC0168 Workgroups. Individual emails were also issued to equipment manufacturers to encourage their participation to Workgroups, this was done early in the process at a request by current Workgroup members. To date none have requested to join GC0168 Workgroups.

d) Consider EBR implications.

It was agreed that there are no EBR changes as there is no impact on the Balancing code.

e) Consider a cost recovery mechanism to receive the model data required to share with a CUSC Workgroup

Discussions have taken place in relation to the cost recovery mechanism, Workgroup members felt that the cost recovery mechanism was difficult to quantify as it would depend on the size of the unit, its age, type and if the manufacturer was still supplying equipment.

f) Consider the use/introduction into the Legal Text of generator classification types C, D as opposed to Medium and Large.

The use of user types was discussed in Workgroups, the Proposer felt that the use of a list would be easier for users and more transparent. As currently drafted the legal text refers to Large, Medium and Small Power Stations as the contractual requirements are based on these terms. Following the implementation of the EU Requirements for Generators (RfG) in the GB Grid Code in 2018, technical requirements were specified based on Type A, B C and D Power Generating Modules as defined in the Grid Code. Although a Large, Medium or Small Power Station could comprise of any combination of Type, A, B, C or D Power Generating Modules, the actual contractual obligation on the Generator under CUSC is with respect to the Power Station not the Power Generating Module, although it is true to say that under RfG the technical obligations are with respect to the Power Generating Module. Noting that this GC0168 modification applies to all Generators, including GB Generators who are not caught by the requirements of RfG, the legal drafting (PC.A.9.2.2) has therefore been based on Power Station size (i.e. Large, Medium and Small) rather than Type A, B, C and D Power Generating Modules.

g) Consider approach on collecting models and where that guidance would sit

This issue was discussed at the Workgroup, members agreed that additional guidance and the approach used could either be included as an appendix to the Planning Code in the Grid Code, under the relevant Electrical Standards or as a standalone guidance note.

The Proposer suggested that including the guidance under the suite of Electrical Standards would be the best approach as this does introduce a governance process (Grid Code GC11) around the document in a simple way. It was noted that if a bespoke Appendix was added to the Planning Code, a full Grid Code modification would be required each time the document needed to be updated which would be demanding in terms of resource and time. It was also noted that a pure guidance note published on the NESO's website would be subject to no governance arrangements. Workgroup members agreed that neither of these options would be viable from an Industry perspective, and therefore the best approach would be to consider including the appropriate guidance as an Electrical Standard. A consultation question has been included on this issue.

h) Consider codifying the list of Users who are required to submit EMT models.

Members agreed this was considered and has been included in the proposed legal text under PC.A.9.2.2. which lists out the Users who are required to submit an EMT model. See **Annex 4**

i) Consider the scenario where a User is unable to provide an EMT model.

This issue was discussed and the proposed legal text updated in PC.A.9.2.2.1 stating that where an EMT model is requested, this is required to be provided within 9 months of a request from NESO unless otherwise agreed in the case of a GB Code User, and 3 months of a request from NESO unless otherwise agreed in the case of an EU Code User. This wording also accounts for potential problems in preparing old plant EMT models that cannot meet all the requirements in PC.A.9. It should also be noted that for GB Code Users and early EU Code Users, a cost recovery mechanism is being introduced to provide a mechanism of compensating Users for the ability to supply a model when requested by NESO. The difference in model submission timeframes between EU Code Users and GB Code User's arises though differences in treatment between EU Code Users and GB Code Users as introduced through the EU Connection Network Codes (RfG, DCC and HVDC Codes). Under the EU Connection Network Codes, there is a requirement for Users to provide a EMT Model when requested from the System Operator, however this is not the case for GB Code User's which accounts for the difference in approach between EU Code Users and GB Code Users.

j) Consider whether there is a need to obtain EMT models from medium power stations embedded in distribution networks and, if so, the mechanism for engaging with the host DNO and the Generator and the process to be followed in the event that the Generator is unable to provide the EMT models or would incur significant costs in doing so.

This was discussed at Workgroup 4 and it was noted this was a particular concern as Licence Exempt Embedded Medium Power Stations (LEEMPS) as they are not CUSC signatories but are bound by some of the requirements of the Grid Code Planning Code through obligations in the Distribution Code. The obligation for LEEMPS to comply with these requirements falls on the DNO, which the DNO would pass on to their LEEMPS customers through the connection agreement. However, as the LEEMPS would have no funding for the provision of the model under CUSC, this would be unfair if generators with a CUSC contract were compensated.

k) Consider whether there is a need for any consequential changes to the DCode and / or DCUSA.

A member noted that it appears that a Distribution Code modification is unlikely to be required for the technical requirements, but there may be a need for a DCUSA modification to deal appropriately with

LEEMPS in relation to any compensation mechanism that might arise from a possible CUSC modification.

l) Consider if we are reflecting international practice including observation of the modelling developments proposed for RfG 2.0 and HVDC 2.0

NESO advised that some additional requirements had been included in the proposed EU Connection Network Codes (e.g. RfG 2.0, DCC 2.0 and HVDC 2.0) relating to EMT models. It was suggested by NESO that these documents were reviewed with respect to their requirements on modelling to reflect international best practice. NESO will review these documents and update the legal text as necessary.

Draft legal text

The draft legal text for this change can be found in **Annex 3**

What is the impact of this change?

Proposer's assessment against Code Objectives

Proposer's assessment against Grid Code Objectives	
Relevant Objective	**Identified impact**
(a) To permit the development, maintenance and operation of an efficient, coordinated and economical system for the transmission of electricity	**Positive** EMT models will be required to carry out analysis such as system oscillation, inverter stability, ToV analyses, especially noting that EPC s require a more detailed model than that available from a current RMS representation. Without being able to conduct this type of analysis using EMT models, it could lead to unnecessary investment by Users or TOs, significant increase in constraint costs, single events leading to tripping of a number of generators and could ultimately lead to loss of supply.
(b) Facilitating effective competition in the generation and supply of electricity (and without limiting the foregoing, to facilitate the national electricity transmission system being made available to persons authorised to supply or generate electricity on terms which neither prevent nor restrict competition in the supply or generation of electricity);	**Positive** As new generation technologies connect to the network, most of which will rely on power electronic converters more detailed

	models will be required not only in respect of the new generation itself but also the impact they have on existing generation. This will drive greater impact on competition.
(c) Subject to sub-paragraphs (a) and (b), to promote the security and efficiency of the electricity generation, transmission and distribution systems in the national electricity transmission system operator area taken as a whole;	**Positive** Due to the increase in EPC s connecting to the grid which is in line with the UK government's Net Zero ambition, this modification will enable a greater volume of EPC s to connect whilst ensuring a more thorough evaluation of the source of oscillations or disturbances and to plan mitigating actions.
(d) To efficiently discharge the obligations imposed upon the licensee by this license* and to comply with the Electricity Regulation and any relevant legally binding decisions of the European Commission and/or the Agency; and	**Positive** Electromagnetic Transient (EMT) analysis is important for investigating the dynamics of converters and control interactions with the System which enables the NESO to meet its license obligations.
(e) To promote efficiency in the implementation and administration of the Grid Code arrangements	**Positive** At the moment we have a need for analysis to be done, and in many cases the obligations for that analysis are on new entrants in the first instance, without a clear ability to receive the data to support the analysis. Then beyond that we have requirements to support the planning and operation of the system which are lacking these same models. This modification will give NESO access to models of already connected Plant

**See Electricity System Operator License*

Proposer's assessment of the impact of the modification on the stakeholder / consumer benefit categories	
Stakeholder / consumer benefit categories	**Identified impact**
Improved safety and reliability of the system	**Positive** When generators provide EMT models to the NESO, it will be able to carry out pre-fault and post-fault analysis studies, the outputs of which will lead to accurate operational decisions in the interest of safety and reliability of the system which could ultimately lead to lower operational costs for the benefit of the end consumer.
Lower bills than would otherwise be the case	**Positive** More accurate models will enable greater Transmission System optimisation which would have the benefit of reducing consumer bills.
Benefits for society as a whole	**Positive** More accurate models will enable greater Transmission System optimisation and reduce the need to run other plant to compensate for inaccurate models.
Reduced environmental damage	**Positive** More accurate models will enable greater Transmission System optimisation and a reduced need to run other plant, some of which could be carbon based which will have a positive environmental impact.
Improved quality of service	**Positive** More accurate models provide greater optimisation resulting in lower bills and therefore improving quality of service

When will this change take place?

Implementation date
10 working days after Ofgem Decision

Date decision required by
September 2025

Implementation approach
No systems will have to change as a result of this modification

Interactions

☒CUSC	☐BSC	☒STC	☐SQSS
☐European Network Codes	☐ EBR Article 18 T&Cs[1]	☐Other modifications	☐Other
☒ DCODE	☐DCUSA		

How to respond

Standard Workgroup consultation questions

1. Do you believe that the Original Proposal and/or any potential alternatives better facilitate the Applicable Objectives?
2. Do you support the proposed implementation approach?
3. Do you have any other comments?
4. Do you wish to raise a Workgroup Consultation Alternative request for the Workgroup to consider?
5. Do you agree with the Workgroup's assessment that GC0168 does not impact the European Electricity Balancing Regulation (EBR) Article 18 terms and conditions held within the Grid Code?
6. Do you have any comments on the impact of GC0168 on the EBR Objectives?

Specific Workgroup consultation questions

7. Do you believe it is reasonable to require those Users identified in the draft legal text in PC.A.9.2.2 to provide an EMT model when requested by the NESO noting the importance of accurate modelling on power system design, operation and post event analysis?
8. Do you believe the timelines proposed for the submission of an EMT model as drafted in PC.A.9.2.2.1 are appropriate.?
9. Do you believe that it is appropriate to set out the renumeration and cost recovery provision of the models in the CUSC?
10. Do you believe it is appropriate to define the detail of the model submission in an Electrical Standard rather than in a specific part of the Grid Code, or as a separate guidance note. If you do not believe this to be the case, please state why you would support an alternative approach?

[1] If the modification amends any of the clauses mapped out in Annex GR.B of the Governance Rules section of the Grid Code, it will change the Terms & Conditions relating to Balancing Service Providers. The modification will need to follow the process set out in Article 18 of the Electricity Balancing Regulation (EBR – EU Regulation 2017/2195). All Grid Code modifications must be consulted on for 1 month in the Code Administrator Consultation phase, unless they are Urgent modifications which have no impact on EBR Article 18 T&Cs. N.B. This will also satisfy the requirements of the NCER process.

11. As part of the electrical standard, it is expected that an EMT model would be submitted in PSCAD Version 5. Do you have any views on this approach and if so, please state what they are?
12. Do you believe that the timeline proposed for the Workgroup meetings and target date of September 2025 are reasonable?
13. Does this proposal deal adequately with LEEMPs?
14. Please could you share your rationale for a cost-recovery mechanism to be put in place supported by evidence, where available. If no cost recovery mechanism were available, what do you believe the implications would be?

The Workgroup is seeking the views of Grid Code Users and other interested parties in relation to the issues noted in this document and specifically in response to the questions above.

Please send your response to Grid.Code@nationalenergyso.com using the response pro-forma which can be found on the GC0168 modification page.

In accordance with Governance Rules if you wish to raise a Workgroup Consultation Alternative Request, please fill in the form which you can find at the above link.

If you wish to submit a confidential response, mark the relevant box on your consultation proforma. Confidential responses will be disclosed to the Authority in full but, unless agreed otherwise, will not be shared with the Panel, Workgroup or the industry and may therefore not influence the debate to the same extent as a non-confidential response.

Acronyms, key terms and reference material

Acronym / key term	Meaning
BSC	Balancing and Settlement Code
CMP	CUSC Modification Proposal
CUSC	Connection and Use of System Code
EBR	Electricity Balancing Guideline
EMT	Electro Magnetic Transient
EU	European Union
GB	Great Britain
HVDC	High Voltage Direct Current
DCRP	Distribution Code Review Panel
EPC	Electronic Power Converter
GCRP	Grid Code Review Panel

NESO	National Energy System Operator
RMS	Root Mean Square
RFG	Requirements for Generators
STC	System Operator Transmission Owner Code
SQSS	Security and Quality of Supply Standards
TOR	Terms of Reference
TO'S	Transmission Owners
ToV	Transient Over Voltage
T&Cs	Terms and Conditions

Annexes

Annex	Information
Annex 1	GC0168 Proposal form
Annex 2	GC0168 Terms of Reference
Annex 3	GC0168 Draft legal text
Annex 4	GC0168 List of types of Users required to provide EMT models
Annex 5	GC0168 Alternative Request
Annex 6	GC0168 Workgroup Consultation Response Proforma