

## GC0137 – SUMMARY OF WORKGROUP RESPONSES

**VERSION 3 – 21/05/2021**

Respondent	High Level Comments	Detailed Comments	ESO Response	Impact on Legal Drafting
EDF	Supportive – Proposal should support all technologies and not be discriminatory	Proposals should be included in a standalone section of the Grid Code	Comments noted – Based on other respondents, the majority favour the inclusion of the Grid Forming requirements in existing parts of the Grid Code (eg PC, CC/ECC, CP/ECP, DRC etc) rather than as a standalone section	None
Drax	Supportive of the proposal	Numerous detailed comments received as track changes to the legal text	Legal Text updated to include comments. These have been highlighted in track change marked format  Where the legal text has not been updated or further clarification is required additional comments are included below.	Legal Text updated
		In terms of the definitions of GBGF-S and GBGF-I which category would a synchronous condenser with a Statcom fit into and more specifically going forward what is the plan for categorisation of combinations?	Synchronous Compensators would be treated in the same way as GBGF-S and a Statcom (if GB Grid Forming Compliant) would be treated in the same way as a GBGF-I. For a hybrid combination the same approach would be used as that adopted for combined storage modules as proposed in GC0096 (Storage) and as highlighted in ECP.10.7, ECP.A.3.1.6, ECP.A.5.1.8 and ECP.A.6.1.10. For compliance purposes assessment would be undertaken when one plant is in service and the other is out of service and visa versa. Additional legal text has been included to clarify this.	Legal Text updated
		How are power swings and oscillatory responses triggered by a system faults without an infeed loss going to be categorised and assessed? Then the more complicated situation where there is a fault and an infeed loss?	This issue was discussed at the workgroup meeting on 10 <sup>th</sup> May. For Plants remote from a fault they will not see the Phase Jump but will see the change in System Frequency and oscillations. Demonstration of compliance can be via achieved by simulations and online monitoring in the period between issue of the ION and FON. It is for this reason why we require good local monitoring	
		Definition of Phase Jump Angle Rating is it not clear what this is and how it can be greater than the	The phase jump angle limit is the operational value at which the plant must remain in the linear mode. If the	

		Phase Jump Angle Limit as this Limit has current limiters activated so there must be the greatest current. Equally how can the peak current rating be higher?	plant has a higher current limit for any other reason then the phase jump angle rating can be a higher value.	
		ECC.6.3.16.1.1 seems to say that GBGF-I are only provide ECC.6.3.19 services and not ECC.6.3.16, how will this work with the commercial arrangements which are currently unavailable. It has been suggested that there will be some sort of day ahead market, but if a user only provides ECC.6.3.19 they will be supplying the service whether or not they are being paid. Or is this saying whilst providing Grid Forming Services ECC.6.3.16 does not apply?	Agree – We propose this clause is removed. In theory if a Grid Forming Plant is able to meet the requirements of ECC.6.3.19.5 it would by default be able to meet the requirements of ECC.6.3.16. Since Grid Forming (through market mechanisms) may not be available all of the time this is not an unreasonable approach.	Legal Text updated
		ECC.6.3.19.3 (i) not sure of the purpose of this paragraph if you are a user you need to comply with these by default.	ECC.6.3.19.3 - It is probably worth retaining this clause as the GB Grid Forming Spec is open to CUSC (User's) and Non-CUSC Parties. If we do not include the requirement in the Grid Code it would need to be included explicitly in the Contract so it is probably best if left in the Grid Code and the contract can then reference it	
		ECC.6.3.19.3 (v)(e) in ECC.6.3.13 there are different RoCoF values some with a measurement period of 500ms others with a measurement period of 1s, what measurement period applies here and which are values are being replaced by the 2Hz/s, also there is a 2.5Hz/s is it being reduced? Would it not be better to take a similar approach to ECC.6.3.16 with ECC.6.3.13. Where ECC.6.3.16, has been copied into ECC.6.3.19.5 and rewritten with the Grid Forming requirements and the statement that ECC.6.3.16 does not apply when providing Grid Forming Services. If a new ECC.6.3.19.x section was written with all the specific number changed as required this would then be clearer.	The legal text in ECC.6.3.13 has been updated to address this issue. A big benefit of GBGF-I Plants enables them to remain connected for frequency changes of 2Hz/s without the equivalent of pole slipping.	Legal Text updated

		ECC.6.3.19.3 (xi) but numbered (vi) the units of MWs should be MJ.	The legal text has been updated to address the numbering. Energy can be measured in Joules or Ws. MWs is probably more meaningful in this case. Energy = Work done = Force x distance = Power x time or Watt seconds. MJ or MWs. Text updated with both units	Legal Text updated
		ECC.6.3.19.4 not really sure why these subsections are not just a continuation of ECC.6.3.19.3, but ignoring that some of the subpoints are not capabilities and therefore the text does not make complete sense.	These have been retained as they are just additional clarifications and hence the new clause number ECC.6.3.19.4.	
		Figure ECC.6.3.19.5(a) should this not be more similar to ECC.6.3.6(a) with the lines come from the bottom left hand corner and not the bottom right hand corner?	We think this comment refers to Figure ECC.6.3.16(a). We had a comment on this issue prior to the issue of the consultation document in January 2021. For a wind farm with a voltage droop characteristic full reactive power export would be expected when the voltage is low which is why the diagram has been updated	
		ECC.6.3.19.5.8 is blocking allowed if the at the agreed overvoltage?	The method in which transient over voltages are managed to be agreed between the ESO and developer. This is designed to be fairly flexible. We would not rule out blocking but would need to ensure that such action does not have unintended consequences on wider network performance in particular impact on active power and the consequential effect on System Frequency.	
		ECC.6.6.1.9 does this requirement apply to both GBGF-I and GBGF-S? Also this a very high sample rate making frequency and RoCoF measurements in half a cycle can this actually be done to any accuracy and are there commercially available instruments with is level of accuracy? This will also create a lot of data what are the data retention requirements for this equipment?	Yes this requirement applies to both GBGF-I and GBGF-S plant. The legal text however has been clarified to address this issue including monitoring and the type of equipment that can be used will also be addressed as part of the Expert Group which will be picked up through the Best Practice Guide.	Legal Text updated
		ECC.6.6.1.10 similarly does this requirement apply to both GBGF-I and GBGF-S?	Yes ECC.6.6.1.10 applies to both GBGF-I and GBGF-S	
		ECC.6.6.3.2 does this requirement apply to both GBGF-I and GBGF-S as there are no tests in the ECP	Yes – See response with regard to the question raised with regard to ECC.6.6.1.9	

		section applying to GBGF-S plant? As before, but this now an extremely high sample rate making frequency and RoCoF measurements in 1ms (1/20 of a cycle) can this actually be done to any accuracy and are there commercially available instruments with is level of accuracy?		
ESO	Supportive	None – other than the preference for the Grid Forming requirements to be integrated into existing parts of the Grid Code	Comments noted – Based on other respondents, the majority favour the inclusion of the Grid Forming requirements in existing parts of the Grid Code (eg PC, CC/ECC, CP/ECP, DRC etc) rather than as a standalone section	None
Siemens Energy	Supportive	<p>It was noted that the cost depends on the final implementation of the source of energy. This includes the size and rating of the system. If it is a separate storage system, then there could potentially be significant additional costs depending on the final configuration. If the energy can be accessed via other means (e.g. energy from a separate AC network in the case of an interconnectors) and the interconnector is not required to overload, then there wouldn't be significant equipment cost.</p> <p>We would say that the European Connection Conditions are best placed to house the requirements given that similar services (e.g. FSM) are also described there.</p>	<p>Comments noted. We believe the proposed drafting as published in the Workgroup consultation is sufficiently flexible to enable developers to enter the future Grid Forming Market without the need to install separate storage systems.</p> <p>We note the preference to include the proposals in the existing sections of the Grid Code as currently drafted.</p>	None
Statkraft UK	Supportive	Consideration should be given to making the requirements mandatory for HVDC Schemes	We note this comment but in GB we are very keen to ensure we do not discriminate between User's or classes of User's and therefore we do not believe it is appropriate to mandate this requirement for HVDC Schemes	
		With grid forming inverter technology, we recognise the need to provide simulations and / or additional test results. However, it should be recognised that as confidence in this type of technology grows, the additional simulations / test results may no longer be required. In particular, hardware tests to verify simulations may no longer be required. Further, EMT simulations may no longer be required, RMS	As part of the proposal we have already have stripped out some of the elements that could be applied to synchronous plant. We will however look further to see if any additional rationalisation can be applied in respect of this issue however we will need to make sure that any plant (including Synchronous Generation) which declares its ability to provide a Grid Forming capability, can deliver against its declared performance.	Legal Text updated

		simulations may be adequate. The new sections of the grid code should be reviewed at a set time (e.g. 2 years) after introduction to ensure that these simulations / tests are not adding unnecessary costs	The legal text has been updated to include the required data in the Planning Code rather than the European Connection Conditions. Where a Grid Forming Plant Owner submits a Manufacturer's Data & Performance Report in respect of the model of the Grid Forming Plant, the developer may subject to The Company's agreement, opt to reference the Manufacturer's Data & Performance Report as an alternative to the provision of the individual data and simulations as required as originally drafted in Table ECC.6.3.19.3.1 and Table ECC.6.3.19.3.2. ECP.7.2.3 also refers to the Manufacturers Data and Performance Report and Equipment Certificates in which a reduced number of tests are permitted. ECP.10 also refers to the Manufacturers Data and Performance Report.	
SMA Solar Technology AG	Supportive – For Storage Systems the costs are modest. For the PV market additional costs are expected due the storage needed but this is a function of the final plant specifications	The term “real power” is mentioned several times. Shouldn't it be active power? That's what the Grid Code usually uses.	Agreed – the legal text has been updated to reflect this. We also note that the term “Real Power” is used in the Grid Code Glossary and Definitions which also needs to be updated to Active Power.	Legal Text updated
		ECC 6.3.13 stipulates a withstand capability of different values for different applications, but each with a different evaluation / measurement time window. This measurement window should be defined here for clarification (e.g. 0.5s or 1s). The term "withstand setting" is still misleading (see our comment SMA_03 from January 2021)	We have received a similar comment on this from Drax Power. The legal text has been updated to reflect this by referring to and amending ECC.6.3.13	Legal Text updated
		ECC.6.3. 19.3 (vii) – Second Paragraph - [...] which should be in the general form shown exemplary in Figure [...]	The legal text has been updated to address this comment.	Legal Text updated
		Figure ECC.6. 3.19.3.2 - The text says, there may be totally different forms. - Add "exemplary" or "preferred" to the beginning for the avoidance of doubt.	The legal text has been updated to address this comment	Legal Text updated
		ECP.A.3. 9.2(d) - Shouldn't this be a “Nicholls Chart”?	Yes – Thankyou for this comment – The legal text has been updated to reflect this comment	Legal Text updated

GE Grid Solutions Limited	Supportive	Comment 1: Page 2/26, Grid Forming Unit definition "...Unit. with a....", remove full stop.	Agreed – legal text updated	Legal Text updated
		Comment 2: Page 2/26, Real Inertia Power definition, 2nd paragraph, definition is not correct for a HVDC system where the active power is provided by the remote station rather than the "...energy storage capability of the Internal Voltage Source."	Agreed – legal text updated	Legal Text updated
		Page 3/26, Peak Current Rating definition, the first two bullets identify the "additional" current but not the total current. Suggest the definition in these two bullets is amended to say "Registered maximum steady-state current plus...."	Agreed – legal text updated	Legal Text updated
		Page 6/26, Damping Factor definition, For better clarity it could be further stated that the damping factor refers to the damping of a specific oscillation mode that is associated with second order system created by the power to angle transfer function as show in Figure ECC.6.3.19.3.2.	Agreed – legal text updated	Legal Text updated
		Page 6/26, CC.6.3.5 Additional test includes "...with a with a..."	Agreed – legal text updated	Legal Text updated
		Page 9/26, ECC.6.3.19.3 (vi), 2nd paragraph, suggest that the last sentence is modified to say "...decays within two cycles of oscillation to within the settling band."	We had had several comments on this aspect and the legal text has been updated	Legal Text updated
		Page 9/26, ECC.6.3.19.3 (vii), 2nd paragraph, text says "...shown in Figure ECC.6.3.19.2 (a) or Figure ECC.6.3.19.2 (b)....". This implies that GBGF-I plant should either be capable of supplying droop based power or damping power, where ECC.6.3.19.3 (iv) presumably requires both features simultaneously. Page 9/26, ECC.6.3.19.3 (vii), 2nd paragraph. Note that the options presented here of "...may use their own design.." is not reflected in ECP.A.3.9.6	Yes we do require both droop control and contribution to damping	

		Page 10/26, Figure ECC.6.3.19.3.1, for clarity it would be useful to indicate the “Grid Entry Point” on the diagram as the point between Xin and Xtr.	Agreed – Legal Text updated	Legal Text updated
		Page 10/26, Figure ECC.6.3.19.3.2 (b) legend says “..This figure does not add damping...” but damping is indicated in the figure?	Thank you for this point – we need to add in does not add in extra closed loop damping.	Legal Text Updated
		Page 11/26, Table ECC.6.3.19.3.1, By “rated angle” does this refer to the angle across Xin for rated power? See figure ECC.6.3.19.3.1.	This refers to the <i>“The rated angle between the Internal Voltage Source and the Grid Entry Point or User System Entry Point”</i>	
		Page 11/26, Table ECC.6.3.19.3.1, Rated voltage should be “pu” rather than “1pu”	Agreed – Legal text updated	Legal Text updated
		Page 11/26, Table ECC.6.3.19.3.2, “Maximum continuous rating” Should this be “Maximum Registered rating”?	The text has been updated to clarify this point. The legal text has been updated to state the Maximum Continuous Rating at Registered Capacity or Maximum Capacity	Legal Text updated
		Page 12/26, Table ECC.6.3.19.3.2, “For a GBGF-I Plant the inverters maximum Internal Voltage Source (IVS) for the worst case condition”, What is meant by worst case condition? Is it meant to state the maximum output voltage that GBGF-I plant can produce under any situation?	For A GBGF-S generator the maximum voltage normally occurs after a short circuit fault is cleared when the AVR plus exciter has increased the generators flux. This condition does not occur in a GBGF- I inverter as the AVR action is suspended and the voltage of the IVS is reduced to provide the short circuit current. The maximum operational voltage from the IVS occurs when the system is exporting reactive current in to the grid with the grid at its maximum voltage condition	
		Page 13/26, Equation1, Suggest referencing ECP A.3.9.4 for duration of inertia response, i.e., energy needs.	Equation 1 referred to in Table ECC.6.3.19.3.2 is at 1 second but the required energy is larger as defined by the frequency ranges for a worst case ROCOF event	
		Page 16/26, ECC.6.3.19.5.11, Should it be “retained balanced voltage” or “unbalanced voltage”, noting that the word retained is normally associated with a balanced quantity	Legal text updated – the word “retained” has been deleted	Legal Text updated
		Page 16/26, ECC.6.6.3.2 (iv), 1MHz seems too high?	Agree – the legal text has been updated to address this issue. This issue will also be raised as part of the Expert Group Best Practice Guide.	Legal Text updated

		Page 17/26, ECP.A.3.9.4 (ii), Should the reference to “full load” be changed to “Registered load”	The legal text has been updated to address this issue	Legal Text updated
		Page 18/26, ECP.A.3.9.4 (iii), “...This is repeated when ...”	Legal text updated	Legal Text updated
		Page 18/26, ECP.A.3.9.4 (iv) (g), Does this imply that in tests ii) and iii) Plant can "saturate"?	The only test where saturation is permitted is under ECP.A.3.9.4 (iii) – where frequency changes of 2Hz/s are permitted but the important point is to remain operational	
		Page 18/26, ECP.A.3.9.4 (v), In case supplier declares rated phase jump angle rating to be higher than phase jump angle limit, shouldn't there be a corresponding test for that?	The extra test should be added to ECCP.A.3.9.4(vi) as this is when the plant would be operating under extreme conditions. A corresponding additional test has also been added to <u>ECP.A.9.1.9.6</u>	Legal Text updated
		Page 19/26, ECP.A.3.9.4 (vii) (a), “...all control actions ....disabled”, It is presumed that current limitation will still be active.	Yes – this is correct. A clarification has been added to the legal text to address this.	
		Page 19/26, ECP.A.3.9.4 (vii) (d), To confirm - FFCI is meant to be disabled for the first iteration of step (a)-(c)	Yes this is correct. Additional clarification has however been added to the legal drafting in this respect.	
		Page 20/26, ECP.A.3.9.4 (iii), Does “all control actions .... disabled” Include FFCI as in ECP.A.3.9.4 vii)	We think this comment refers to ECP.A.3.9.5(iii). This simulation refers to a coincident fault and frequency disturbance at the same time. For this simulation, FFCI and Fault Ride Through should not be disabled as there are no repeat tests for these requirements to assessed.  There is a limit to the number of tests that can be completed but the finer detail will be covered in the Best Practice Guide	
		Page 21/26, ECP.A.3.9.6, Note, in clause ECC.6.3.19.3 (v).f.(vii) the vendor is also permitted to use their own mode	Agreed – the legal text has been updated to reflect this.	
Enstore	Supportive but notes that the incorrect reference made to GC0137 in question 1	Page 21/26, ECP.A.3.9.6 (iii), It is not understood what overshoot and decay mean in the context of a harmonic disturbance.	These tests relate to the assessment of damping and damping factor not to quality of supply or harmonics.	
		Two detailed comments have been made. These relate to the Inertia Constant H and He as applicable to Grid Forming Inverter Plant. These changes need to be reflected in the Glossary and Definitions, Table	The legal text has been updated to reflect these comments	Legal Text Updated



	of the workgroup consultation	ECC.6.3.19.3.2, Equation 1 and Equation 2 below Table ECC.6.3.19.3.2  In addition, updates have been suggested to the Glossary and Definitions for the term Peak Current Rating		
Sygensys	<p>Overall Supportive.</p> <p>There is a potential issue with GC0141 which is an error with the Workgroup Consultation question.</p> <p>A comment has been made that making the requirements mandatory may in the longer term result in lower operating costs and greater Grid resilience</p> <p>Reference has been to Smart Loads which could provide a Grid Forming Capability. This issue is addressed in the detailed comments.</p>	Introducing requirements for bode plots is a good step forward to adopting some of the tools from a control systems approach to stability analysis. “To supply relevant data (Network Frequency Perturbation Plot and Nicolls Charts or equivalent) so that the ESO can verify that the plant will not have any negative interactions with the Transmission System or other User’s Plant and ensure an adequate level of damping. “	We accept and agree with this comment. The legal text however has not been updated in respect of this item.	Some of these comments can be included in the workgroup report
		Ideally plots and modelling capability should consider the frequency range up to 1 kHz. This is so that it includes performance at low harmonic frequencies and allow analysis at the 5ms response time specified for step change response.	The current models and analysis as part of the frequency NFP Plots and Nicholls chart will be discussed by a separate “Expert Group” who are charged with the preparation of e “Grid Forming Best Practice Guide”. The 1KHz only relates to the phase jump response and nothing to do with harmonics.	
		It should be noted that direct measurement of inverter based resource frequency response is possible. For example, see the work of Lingling Fan for example <a href="https://naspi.org/sites/default/files/2021-04/D1S3_01_fan_usf_naspi_20210413.pdf">https://naspi.org/sites/default/files/2021-04/D1S3_01_fan_usf_naspi_20210413.pdf</a>	This is an issue which can be picked up as part of the Best Practice Guide. We do not believe that it needs to be reflected in the Grid Code.	
		Should UK grid research and test community consider a similar facility in UK? This would allow independent verification on manufacturers measurement and simulation models. It should be noted that a high-power inverter-based plant is often made up of many lower power inverters. Testing individual inverters can make a valuable contribution.	Again this is an issue that can be discussed as part of the Expert Group in developing the Grid Forming Best Practice Guide but it is more likely that it needs to be picked up by the major manufacturers	

		Page 20 “The “outer” control loops do not include the “inner” parts of a GBGF-I’s control system which emulate the inertia and damping functions provided by a real Synchronous Generating Unit. “	This has been clarified in the Legal Text	Legal Text updated
		Would it be better to specify required performance in terms of gain and phase margin, rather than basing around the derived term damping factor? These parameters are likely to be directly available from simulation and measurement.	These issues are already taken into account in the Nicholls Chart. Bode Plots, Nicholls Charts and Nyquist Plots can all be used to derive the phase and gain margin it is just they are presented in a slightly different format.	
		As we move towards 100% inverter-based grids it would be good to drop historic terms, such as torque (mentioned in multiple places in the document), and replace with terms which are more applicable to modern IBR grids. Similarly, the term inertia is often mis used. Most IBR resources, operating below 100% capacity, can provide fast acting power reserve, without the need for the typical inertial recovery period. This should be used as a benefit not forcing IBR to emulate inertia and not using the term inertia.	We would note that the specification is designed to cover a wide range of technologies these being both traditional synchronous technologies and more modern power electronic converter based technologies. We have a number of new terms defined in the Grid Code to cater for Grid Forming Technology which is designed to be applicable for both synchronous and converter based plant	
		Page 37 fig 14 The impact of the changing nature of load should be considered as part of grid stability. The reduction in synchronous load and increase in constant power loads will have a significant impact. Converter technology in loads and power factor correction make them look nicely resistive at line frequency, but the impedance changes rapidly in the region below 10Hz to with many loads becoming constant power for low frequency variation. To the best of my knowledge the effect on grid small signal stability has not been considered in any depth.	These are comments on the workgroup report which we can include in an updated version of the workgroup report. This will follow ahead of presentation to the Grid Code Review Panel and the Code Administrator Consultation. We would however note that there is no change to the legal text as a result of this comment.	
		Grid following inverters have a bad reputation due to PLL unlocking. It is important not to blame the concept of a PLL. The issues relate to implementation. Grid forming inverters will include PLL functionality to allow tracking of grid phase.	These are comments on the workgroup report which we can include in an updated version of the workgroup report. This will follow ahead of presentation to the Grid Code Review Panel and the Code Administrator Consultation. We would however note that there is no change to the legal text as a result of this comment.	

		Inverter based resources in most renewable generation cannot provide any sustained reserve power, unless their output is deliberately curtailed most of the time. This is not economically or environmentally efficient. Greater use of fast demand side response services could provide an alternative grid stability service in case of unplanned loss of generation.	Thank you for this comment. We can include this in the updated version of the Workgroup Report	
		<p>Page 21 “The impedance would be real being made up of either one or a string of real impedances between the internal voltage source and connection point and would not comprise virtual impedances.</p> <p>This implies that the inverter has zero source impedance, without specifying a frequency range. Zero is unrealistic, should the limit be the virtual component is 10% max and over a defined frequency range?</p>	<p>We do not want any software which acts to control the Internal Voltage Source (IVS) to produce an equivalent to real impedance that we call synthetic impedance. The reason is that this requires high bandwidths which affects the Internal Voltage Source.</p> <p>If the supplier knows the actual real impedance values of the IVS they can be used in the equations</p>	
		Page 29 “The resolutions required to record these events are small. For a Grid Forming Converter with a fundamental frequency of 50Hz, a complete cycle takes place in 20ms which is equivalent to $2\pi$ radians or 360 degrees. Therefore a 5 degree change would take place in a timeframe of $(5/360) \times 20\text{ms} = 270\mu\text{s}$ and a 1 degree change would take place in $54\mu\text{s}$ . Therefore to accurately record these sorts of phase shifts, a sampling time of $1\mu\text{s}$ (1MHz) is likely to be required.”	Thank you for these comments. We have had a number of comments on this issue and revised the legal text to reflect this and other Workgroup Respondents comments. The legal text (ECC.6.6.3.2) has now been updated to state that for Grid Forming Tests, measurements should be to an agreed standard which shall be agreed with NGESO. We expect this issue to be addressed as part of the Best Practice Expert Group.	Updated Legal Text
		A phase change could be near “instantaneous” with appropriate voltage steps on the phases. In a 3-phase system phase can be measured instantaneously from the 3 phase voltages. The requirement for measurement could be based on the highest frequency component specified in the specification. I believe this is comes from the response time specified in document is 5ms.	See above comment	

		<p>“Dynamic System Monitoring Specification TS.3.24.70_RES” Specifies a sampling rate of 12.8 kHz and allowing for anti-aliasing this should provide accurate phase information at a rate of several k sample per second. This is likely to be ample to verify performance against the specification.</p>	See above comment	
		<p>Page 27 and 28</p> <p>“purpose is to assess the correct supply of “ROCOF Response Power” without going into saturation and that pole slipping does not occur.”</p> <p>It is important to consider the performance of the plant well outside the linear region. This should specifically look for large undesired response characteristics similar to pole slipping in a synchronous machine or PLL unlock in a grid following inverter.</p>	The test at the ROCOF withstand limit will test the equivalent of pole slipping withstand capability and that it does not occur.	
		<p>This should include a clearly define list of fault conditions such as Open circuit phase Phase to GND short Phase to phase short Fault ride through Harmonic Voltage step</p> <p>It is great that the document highlights the need to learn from international experience.</p> <p>Regarding the approaches to modelling I would highlight the following document.</p> <p>This address many techniques that can be used to improve the modelling of complex inverter-based resources. This has particular emphasis on the use of EMT modelling and the accuracy of modelling, not just from frequency response, but also for fault cases which are not handled well by positive sequence phasor simulations.</p> <p>Annex 9 Page 6 “Converters that use the Phase Locked Loop technology to keep their generated power constant when changes occur in the phase angle of the AC grid. This technology stops them</p>	<p>See above Comment</p> <p>Thankyou for these comments. We will include the references in the updated version of the report.</p> <p>The more detailed aspects of modelling will be picked up as part of the Best Practice Guide that will be prepared by the Expert Group</p> <p>Thank you also for this comment which is very helpful.</p> <p>A PLL used in the conventional way that changes the phase of the IVS rapidly when a phase jump occurs in the Grid is</p>	

		producing the 3 Types of Phase based power.” A PLL does not stop an IBR producing a damping effect. Choice of PLL control loop bandwidth is critical. Don’t blame the PLL, even grid forming inverters will include a form of PLL.	not permitted. A PLL used for other purposes is allowed in the control	
		<p>Annex 9 Page 5</p> <p>The distinction between type 1, 2 and 3 could be clearer. My preference would be along the lines:-  Type 1 Step change in phase  Type 2 Linearly changing frequency (or RoCoF) (Using the term inertia can be confusing as it defines the response not the cause)  Type 3 Oscillating change in phase, at a frequency less than line frequency  Type 4 Control based is a confusing term, because in in an IBR all these powers are controlled.</p> <p>Why is linear changing in phase (fixed frequency offset) is not mentioned as part of this analysis? Is it assume droop performance is unchanged?</p> <p>Note that type 1, 2 and 3 powers identified above may be limited in the case where frequency is already low. For example available type 2 RoCoF power for a IBR will be less at 49.5Hz than it would be at 50Hz, because the IBR will already have increased its power due to droop settings and be closer to its current limit. In comparison inertia power for a synchronous machine is largely unchanged by frequency due to the temporary overload capability.</p>	<p>Annex 9 relates to a separate document that was prepared by one of our workgroup members. We will raise this issue with him and ask him to consider these issues. We have discussed these issues with him and these are issues which need to be included in the Best Practice Guide being prepared by the Expert Group.</p> <p>We are aware that following the issue of the latest specification the Guide in Annex 9 requires updating, however it is expected that these issues will be picked up as part of the Expert Group</p> <p>See above comment</p> <p>See above comment</p>	

GE Renewable Energy	Overall Supportive but with suggested comments and Alternatives		Based on the on the responses in both the consultation and Alternatives it looks as though you have commented on the draft version of the specification dated 21 December 2020 rather than the updated version issued as part of the consultation (Annex 10) dated 30 <sup>th</sup> March 2021. The version of the legal text dated 30 <sup>th</sup> March 2021 already takes many of your comments into account but we have taken the opportunity to consider your comments and update the latest version of the legal text to address any outstanding comments you have raised.	
		On the Glossary - Definition of Voltage Jump Reactive Power: The definition of this parameter includes a dynamic requirement requesting instantaneous supply of voltage jump reactive power as a result of a voltage magnitude change. Background and intention of this dynamic requirement is unfortunately not fully clear. For other parameters like e.g. phase jump active power, dynamics are defined in the quite clear way that a response should start within less than 5 milliseconds. It is unfortunately unclear why is this kind of specification was not used for the voltage jump reactive power and a quantitative dynamic requirement would be appreciated.	We have amended the legal text to include a quantitative dynamic requirement in the definition.	Updated Legal Text
		On the Glossary – Definition of Control Based in conjunction with ECP.A.3.9.6: The draft in conjunction with the provided guidance document provide quite clear information that a 5 Hz control bandwidth requirement shall be applied. Unfortunately, the draft does not provide details on quantitative acceptance criteria for meeting this requirement. It would be an important improvement and help to understand the tolerance around the 5 Hz control bandwidth limitation more clearly.	This issue and quantitative acceptance will be addressed in more detail as part of the Expert Group Best Practice Guide. The definition of “control based” was substantially updated as part of the last iteration of the specification and included in the Workgroup Consultation dated 30 <sup>th</sup> March 2021. In addition, ECP.A.3.9.6 has been substantially updated to define the test signal.	Updated Legal Text
		On ECC.6.3.19.3 (vi): In general, the entire draft includes a lot of well-defined quantitative requirements. Unfortunately,	This issue was addressed as part of the latest specification (included in the consultation document and dated 30 <sup>th</sup>	Updated Legal Text

		<p>the damping requirements for the active power output and reactive power output following a disturbance just refer to the term “adequately damped” without giving a clear definition what “adequately damped” shall quantitatively mean (e. g. minimum damping ratio). In general, we would appreciate if this ambiguity could be eliminated, but maybe there is some background information available why just the term “adequately damped” was used in this clause and not specified more in detail.</p>	<p>March 2021). Following further comments from stakeholders this issue has subsequently been updated.</p>	
		<p>On ECC.6.3.19.3 (viii): From reading this clause and the draft requirements in general, it is not fully clear if the model structure shown in Figure 3.0 labeled “Typical Simulation Model” is</p> <ul style="list-style-type: none"> <li>a) the only one that shall become acceptable and must be supported by any technology or</li> <li>b) if this is an example and users / vendors have flexibility for providing an equivalent model of their Grid Forming Plant.</li> </ul> <p>Some clarification on this item would be appreciated. In general, we would like to strongly recommend keeping model structures in this early phase of grid forming technology implementation as open and flexible as possible.</p>	<p>This is an example only and Users/Vendors have flexibility for providing an equivalent model. This is clearly stated in the legal text.</p>	
		<p>On Appendix ECP.A.3.9. The Appendix provides an outline about the compliance process but unfortunately does not include detailed information on a) how simulation and/or measurement results shall be assessed and on b) acceptance criteria. Assessing simulation and/or measurement results should be carefully considered as the performance parameters to be</p>	<p>As noted there have been a few changes to the specification (including ECP.A.3.9) since the published version dated 30<sup>th</sup> March 2021. Once approved the Grid Code is quite difficult to change so we are trying to keep the document reasonably high level with the detail which will include acceptance and performance covered by the Expert Group and Best Practice Guide.</p>	

		checked (“within less than 5 ms”) fall within the same time domain as a lot of other transient phenomena creating noise around the data of interest under assessment (switching transients, DC offsets, harmonics , etc.). And for acceptance criteria it can make a significant difference if performance and compliance get evaluated by assessing 1ms (“instantaneous”) values or RMS values (over 20ms) or floating 50ms average values, etc. Some information on how and when details on a) and b) shall be developed more in detail and published would be very helpful.		
		Alternative 1 - ECC 6.3.19.3(v)(a): Suggest adding language to this requirement: ‘Asymmetric response is permissible when required to respect equipment limitations or asymmetry in energy availability’. Opening the requirements to an asymmetric response could enable a larger service capability and could avoid that available capabilities get deliberately excluded from service arrangements.	The Legal text has been updated to address this comment.	Updated Legal Text
		Alternative 2 - Adding language for defining the calculated as per the method for reactive fault current in line with IEC 6100-21:2008	<p>We have some concerns over this Alternative. IEC6100-21:2008 is a standard which covers the definition and specification of the quantities to be determined for characterizing the power quality of a grid connected wind turbine. It has also now been replaced by IEC 61400-21-1:2019.</p> <p>We note that you have stated ““Reactive current is to be calculated as per the method defined in IEC 61400-21:2008, whereby the positive sequence and negative sequence reactive current components of the fundamental frequency (50Hz) are separated out.”</p> <p>We also note your reference to the example in Australia. In a true Grid Forming plant, reactive current would be expected to be injected almost instantaneously and this is a fundamental part of the requirements of this modification. The example from Australia refers largely to Grid Following</p>	We do not agree with Alternative 2.



			<p>and this is more similar to the requirements of ECC.6.3.16 which was discussed at length as part of Grid Code modification GC0111. As part of this modification (which included many of the major manufacturers) one proposal was considering the option of IEC50549 but this was rejected by the workgroup for the reasons laid out in GC0111. There are potentially two issues here these being i) the actual requirement itself and ii) the compliance and assessment method. Details of compliance and assessment will be picked up as part of the Expert Group Best Practice Guide however the requirement for reactive current injection performance requirements would need to be achieved in the less than 5ms timescales required. You are welcome to raise an alternative but you will need to define how the legal text should be amended and why following IEC 61400-21:2008 is better than the proposed solution and how this method demonstrates a true grid forming capability in the required timescales (ie less than 5ms). <i>We would also note that in doing so would potentially result in significant delays to the delivery of the Grid Code modification which we would not recommend when the issues you raise could be picked up as part of the Expert Group.</i></p> <p>We also note that it is possible the legal text as commented on was the version dated 21 December 2020 rather than the version in the consultation document which is dated 30<sup>th</sup> March 2020</p>	
		<p>Alternative 3 - The proposal is to add the following language to clause ECC 6.3.19.5.1: "Exceptions to this reactive current injection levels are allowed when significant active current is drawn by loads and/or resistive components of faults or other components."</p>	<p>We think this issue is already addressed in ECC.6.3.19.5.3. However we agree that some further clarification is necessary and the legal text has been updated to include wording similar to that suggested.</p>	Updated Legal Text
		<p>Alternative 4 - Proposal to change the following language in clause ECP.A.3.9.6:  "To demonstrate the Grid Forming Plant model is capable of contributing to Damping Active Power, the</p>	<p>This issue was addressed in the previous iteration of the specification dated 30 March 2021. A minor amendment has been made to the latest version of the legal text to state that the parameters can be agreed between the ESO and User/Non CUSC Party</p>	Updated Legal Text

		<p>Grid Forming Plant owner is required to supply a simulation study by injecting a sinusoidal test signal into the Grid Forming Plant model as supplied in ECPA.3.9.2. The frequencies used for this test signal shall be agreed between the Company and the User or Non-CUSC Party. The results supplied need to verify the following criteria. ....”</p> <p>The main difference is that the alternative solution provides a more flexible and open requirement for this kind of compliance simulation while the original proposal just stated a single frequency of 2 Hz without any tolerances.</p>		
		Alternative 5 - Alternative proposal for ECP.A.3.9.5: Additional Figure for grid forming plants which are not subject to a black start contract.	You have commented on the version of the specification dated 21 December 2020 rather than the consultation version dated 30 March 2021. Figure ECP.A.3.9.5 was updated between 21 December 2020 and 30 March 2021 and now utilises a test Grid rather than a machine. We suggest you look at the revised text and advise if this addresses the concern.	Updated Legal Text
SP Energy Networks	Supportive	This modification deals with new technology that the industry as a whole is only beginning to understand. It seems likely that the minimum specification may need to be revised in the near future, so the working group might give some thought how best to implement this modification now while recognising possible future changes.	We fully agree with this comment. Our aim is to keep the Grid Code specification as high level as possible and cover the detail in the Best Practice Guide which will be developed by an Expert Group. The aim is to update the Best Practice Guide in lieu of the experience gained which should help to minimise future Grid Code changes.	
		A specific issue that may need to be addressed in future revisions is the negative phase sequence impedance of converters and the effect on system unbalance, both in normal operating conditions and in response to faults or other disturbances. The proposed legal text is limited in what it says on this issue.	We agree with this. The present drafting provides for compliance with the current quality of supply requirements as covered in CC/ECC.6.1.5, 6.1.6 and 6.1.7 with additional requirements specified in the Bilateral Agreement. We believe this is fairly high level but should be sufficiently flexible going forward. We also hope that these issues will be covered in more detail as part of the Expert Group which will add further detail to this area.	

		The consultation document notes the requirement for models to be incorporated into the ESO's software for power system analysis. It may be useful to also note that those same models will be shared with other transmission licensees, and that additional modelling information may be requested through the Bilateral Agreement. It may also be necessary to share models and data with third parties, as already provided for in industry codes, so it may be useful to explore the level of confidentiality that may be attached to the data being requested.	The STC and STCP's provide for models to be shared for this purpose. We see that Grid Forming is no different to this and will be an important part of this process. We would note that models can currently be shared under STCP 12-1 and STCP-22-1.	
		These new requirements are likely to require revision and refinement in the near future as the industry comes to understand the implications and opportunities more fully. As such, a new standalone section may be better to allow further modification while minimising complex interaction with other parts of the Grid Code.	We note this comment. There has been a mixed response to this question but overall the majority appear to favour placing the requirements in existing parts of the code.	
		Yes. Future revisions seem likely and it will be easier to accomplish this in a Best Practice Guide. Details can be incorporated into Grid Code if appropriate once settled.	We note this comment and are very supportive of a Best Practice Guide and formation of an Expert Group	
		It is preferable for all parties to face the same requirements, irrespective of technology type, to help ensure a fair and open market for services. This is a non-mandatory technical specification and there is no expectation of retrospective application to existing synchronous generators. The issue should be explored further in the proposed Expert Group	We note this comment. We have had conflicting comments on this issue but agree that it is something that can be discussed further as part of the Expert Group who will develop a Best Practice Guide..	
ScottishPower Renewables	Supportive  Agrees that the approach should be non-mandatory with market based remuneration based principles and	SPR would also like to highlight that GB GF provides a number of benefits for the system operation that go beyond the usual recognised inertia capabilities. In order to incentivise the participation of a wider range of technologies, the remuneration incentive around GB GF should be flexible and remunerate each of these capabilities. Avoiding a black and white approach that may push back providers that	We note and acknowledge this comment. As noted however the GC0137 Workgroup is aimed at developing a minimum Grid Forming Specification and the remuneration aspects will be picked up via a separate workgroup. We will note this issue in the workgroup report so it is addressed by the group who subsequently develop the market arrangements.	

	<p>implemented as soon as possible ideally by October 2021.</p> <p>Agree and support the views of Siemens Gamesa Renewable Energy (SGRE)</p> <p>Supportive of the issue of a Best Practice Guide</p>	are unable to fulfil the full extent of the specification will be critical for the success of the roll-out of GB GF. However, SPR understand these considerations may not be part of the scope of this proposal.		
		At the moment, SPR is still to understand the extent of the additional costs although that's certainly subject to the time in which developers and technology providers decide to enable the capabilities (i.e. early stage of design, retrofit, etc.). SPR do think that any additional costs out of enabling the grid forming capabilities should be remunerated through market mechanisms that provide a signal and incentive to developers to undertake changes in the design of their power plants.	We agree with this comment and support the provision of a market which has been promoted in the workgroup consultation.	
		As the proposal is for a non-mandatory services, SPR believe it would be better to have a new standalone section in the Grid Code similar to the Demand Response Services Code. This would make it consistent as a non-mandatory service and avoid confusions about the responsibilities on generators.	We note this comment. However from all the responses received there was a bias in favour of integrating the requirements into the existing sections of the Grid Code so we will be adopting this approach.	
		SPR understand there are inherent differences between GBGF-S and GBGF-I technologies and agree that some dynamical performance characteristics are already understood for GBGFS while not so much for GBGF-I. SPR also agree that would be inefficient and not cost effective to mandate testing /analysis to those plants with characteristics that are well understood. However, SPR would encourage NGESO to promote a level playing field between technologies and advocate for removing some	We note this comment. We will work with the Workgroup and Expert Group to see if any further simplifications can be made and see if this can be picked up as part of the Expert Group in developing a Best Practice Guide.	

		preconceptions on GBGF-I technologies that could turn to be disadvantageous for the industry and its participants. SPR hope that NGESO would build the confidence on the performance on this technology along with supporting key technology players.		
		Difference between grid forming (GF) and virtual synchronous machines (VSM): There is some confusion between GF and VSM. VSM, which is part of the GF family, is based synchronous generator (SG) performance in different degrees depending on the implementation. GF means that the power converter can sustain a voltage at its terminals without any external measurement. VSM, as it is inspired by the SG, can provide inertia and react to frequency disturbances. We should keep in mind that other GF implementations can provide VSM like services.	We agree with this statement. We have tried to make the specification as flexible as possible to promote all types of technology. We have also updated the legal text to include any type of plant and apparatus which could include a smart load. The specification as drafted (Table ECC.6.3.19.3.2) requires any developer to submit their plant data – irrespective of being VSM, VSMOH or simply providing instantaneous fault infeed. In other words the requirement as currently drafted provides for a full or part Grid Forming capability and the market arrangements will subsequently define which plants (and their associated capabilities) are used in the operational timeframe. We have also updated the legal text to confirm that in a GBGF-I the power converter can sustain a voltage at its terminals.	Updated Legal Text
		References to VSM and VSMOH: It has been proved in relevant literature that other current control-based implementation might offer similar or better performance to VSM. In the case of VSMOH, it is the same as the standard grid forming current control with droops extensively used in microgrids. NOTE: grid forming current control configurations have been used very successfully in microgrids.	We note this comment. The current specification makes no reference to VSM or VSMOH. With regard to the equivalent models (Figure ECC.6.3.19.3.2(a) and Figure ECC.6.3.19.3.2(b) the legal text does state “ <i>When submitting either Figure ECC.6.3.19.3.2 (a) or Figure ECC.6.3.19.3.2 (b), each User or Non-CUSC Party can use their own design, that may be very different to Figures ECC.6.3.19.3.2 (a) or ECC.6.3.19.3.2 (b), but should contain all relevant functions</i> ” to give some flexibility around the model submitted. We have also taken the opportunity to update the legal text in ECP.A.3.9.6 to ensure developers have flexibility in the models they submit. We also agree that this issue will be discussed in significantly more detail as part of the Best Practice Expert Group.	Updated Legal Text
		Complexity of the model: The document uses a very simplified model of the synchronous machine and power converters representing their dynamics below 50Hz. There is the concern of falling into unnecessary simplification and specifying the	We welcome this comment and do agree that it is a very simplified model. Our aim is to try and make the Grid Code as high level and as flexible as possible, the aim being to minimise as far as possible, repeated changes to the Grid Code specification. The text has been written so that it	

		requirements that might fit an ideal network rather than the real network.	states that developers can use their own design which may be very different to the figures We expect the detail of models will be picked up as part of the Best Practice Guide but we hope the model and Grid Code drafting is sufficiently flexible for models to evolve in the future.	
		Definition of "Grid forming capability" (GFC): The document defines GFC as "Active Power output is directly proportional to the magnitude and phase of its Internal Voltage Source, the magnitude and phase of the voltage at the Grid Entry Point or User System Entry Point and the sine of the Load Angle." SPR believe this equation represents the active power transferred between any two voltage sources, independently of the used control method. The key point of GF is that the converter can sustain a voltage at its connection terminals. This is not reflected in the document. SPR might argue that all the converters have an "Internal Voltage Source" but in GF, this voltage source might not depend on the network for the fundamental voltage controllability.	We agree with this comment and have updated the definition of "Grid Forming Capability" in the legal text.	Legal Text Updated
		We also believe that grid following also is compliant with the following statement: "As a consequence, a Plant which has a Grid Forming Capability is one where the frequency of rotation of the Internal Voltage Source is the same as the System Frequency for normal operation, with only the Load Angle defining the relative position between the two." We are concern that these definitions may not be too accurate.	We disagree with this statement as we do believe it is accurate. This should not be confused with phase differences. It is however something that can be addressed as part of the Expert Group who will develop a Best Practice Guide.	
		Time response requirement: the document should specify all the time response requirements. For example, it is established that for the "phase jump active power" the power should be provided in less than 5 ms but there is no mention of the ROCOF time response requirements.	The legal text has been updated to address this.	Legal Text updated

		5Hz bandwidth consideration and voltage stability: when comparing to SG, Power converters represent a richer frequency characteristic and can provide a faster response than SG. Limiting the bandwidth of the outer loop of the converters to 5 Hz might impact the ability of the power convertor to support the network. Simultaneously, the document does not specify the voltage support capabilities that the converter should present, for example, voltage oscillation damping.	The Legal Text has been updated to address this	Legal Text updated
		Consideration on testing and the converter control gains: Power converters can vary their response by returning the control gains. For example, by changing the H of the controller, more inertia can be provided. This should be understood as an advantage rather than a disadvantage as the converter response can be tailored depending on the grid conditions. The document is based on the approach that parameters will be not changed. The testing should include some kind of sensitivity analysis.	Table ECC.6.3.19.3.2 defines the parameters to be submitted by a developer which includes H values. Many of these values will be dependent on the gains in the control system. So far as compliance is concerned, at its highest level we simply need to have some assurance that the plant as built is capable of meeting the declared parameters which would not preclude the developer from changing the gains. We agree that there may be some need to consider a sensitivity analysis but we feel this issue is best addressed through the best practice expert group rather than an amendment to the Grid Code legal text.	
		Control interactions: It is suggested that the Network Frequency Perturbation technique should be applied to get the small signal frequency response. This method only provides information about potential interactions when the frequency of the network changes, but the voltage stability is ignored. From a converter control perspective, the converter might likely suffer more from voltage stability issues than active power interactions. Also, it is not clear what should be done to assess the stability of the network using these plots as they only represent the dynamics of a single converter.	Yes this is a key topic that needs to be addressed by the Expert Group through the Best Practice Guide	
		Future proofing the system: the specification will unlock converter capabilities to support system stability by aligning their performance to SG in an attempt to maintain system operation as it stands	We agree with this statement that the Transmission System and Total System will continue to evolve and change as more and more converter based plant continues to dominate the electricity generation sector. We do not	

		<p>nowadays. Future work from NGESO and working groups should question the operation, control, and protection requirements of the future (and present) power network where SG will represent a small part of the generation units. NGESO, and the industry, need to take on the opportunity to start to define the operation of converter dominated networks in order to try to undertake least regrets decisions that will likely impact the future system costs.</p>	<p>believe this will require a change to the legal text but agree that it will require constant assessment. We believe the best starting point to address this issue is the Best Practice Expert Group and the recommendations coming out of this work would be the "GB Grid Forming Best Practice Guide" in addition to recommendation to the wider industry as to how the system can be operated in a safe, secure and economic manner against the background of an increasingly dominant converter environment.</p>	
		<p>Uncommon terminology: "ROCOF Response Power", "Phase Jump Active Power" are not common terms in electrical engineering. It might be better to specify the power requirements in terms of synchronising and damping power.</p>	<p>It would be worth making this comparison as part of the Expert Group as there is no clear definition of Synchronising Power</p>	<p>We will consider how we can update the legal text</p>
Vattenfall	<p>Supportive</p> <p>Supportive of non mandatory requirements</p>	<p>GBGF-I = IVS behind an impedance. Hardware now is the same ie converter IVS behind filter+trafo inductance. Must have ability to change Volt &amp; Ph. Impt to note that not immediately react rapidly to changes in the grid phase for Normal Operating conditions.</p>	<p>We note this statement</p>	
		<p>GBGF-I = must provide (i)phase jump + (ii)inertial/rocof + (iii)damping + (iv)control power. Although (ii-iv) can be provided with traditional grid following (PLL synchronized) units with outer controls, (i) requires voltage vector control instead of current control &gt;&gt; avoid high BW D+Q loop? (Enstore Guide 8.5 p24)</p>	<p>A PLL used in the conventional way that changes the phase of the IVS rapidly when a phase jump occurs in the Grid is not permitted. A PLL used for other purposes is allowed in the control</p>	
		<p>Avoid use of PLL as it prevents the output power of converter responding to changes in grid phase angle. (WG Consultation pg.7 &amp; Enstore Guide 8.5 p24) &gt;&gt; slow down the PLL as it leads to fast converter ph changes to match grid phase changes? (fit VSM structure into PLL loop)</p>	<p>A PLL used in the conventional way that changes the phase of the IVS rapidly when a phase jump occurs in the Grid is not permitted. A PLL used for other purposes is allowed in the control</p>	



		Is PLL still present as VSM uses PLL for RocoF Power (Fg measurement, shown in WG Consultation fig.9 p23), which is not used in normal operation as power-based synchronization? However VSMOH does not require any PLL (no inner loop?) similar to droop << How does GBGF apply to islanding operation?	A PLL used in the conventional way that changes the phase of the IVS rapidly when a phase jump occurs in the Grid is not permitted. A PLL used for other purposes is allowed in the control	
		For GBGF- I systems that have a source of continuous power, like wind and solar power systems, it is essential that an independent fast acting energy store is used inside the system to ensure the correct delivery of the RoCoF response power and to avoid the “Double Frequency Dip” effects produced by the designs of some existing static Power Converters””” (Enstore Guide 8.5 p18) << relevant for onshore/HVAC WPP directly connected to grid; HVDC-OWPP may require storage (or wind spill) to support MMC GBGF-I.	This is correct though an alternative solution is to deload the plant (ie pre curtail) rather than using storage. This may be attractive under conditions when wind or solar resources are high and electrical system demand is low which would enable the service to be delivered at a competitive cost without the need to install large volumes of storage which could be an expensive option. There is nothing to stop a developer or offshore developer to install additional storage should they wish to.	
		It will also need to be clarified if some or all of the “Technical Performance Requirements”, will have to be met if a Generator/HVDC converter has opted to provide GB Grid forming services.	The technical requirements have to be met but there is flexibility in this in relation to the parameters that the developer submits for its grid forming plant (see Table ECC.6.3.19.3.2) which would be reflective of its capability. For example, a developer could have a VSMOH plant and the parameters submitted are reflective of its capabilities. We have been very keen to make sure the specification is flexible so we get a number of parties offering a service based on what their individual plant is capable of rather than a rigid specification that could be costly to implement. If this approach had been adopted it potentially has the risk of making some technologies (which are good at some elements) uncompetitive.	
		We agree that Grid Forming Capability should also include large scale HVDC Converter stations [as planned for the future connection of offshore windfarms]. However the OFTO regulatory framework will need to be changed to allow such	As part of the legal drafting, HVDC Systems are able to offer a Grid Forming Service if they wish to though we acknowledge there may need to be a change to the OFTO regulatory framework. At the last Workgroup meeting held on 10 <sup>th</sup> May this issue was noted and it was suggested that it should be included as a recommendation in the GC0137	

		large HVDC assets to participate in the proposed commercial market.	workgroup report so that it could be picked up by other industry working groups and fed back to Ofgem and BIES	
		Hybrid Power Plants [ie a combination of wind, solar, battery] could also be included as an aggregated unit to provide GB Grid Forming & blackstart.	We agree and note this statement. The current drafting does not prohibit this from taking place.	
		Black-start capability could also be one of the services that a large HVDC converter/windfarm could provide, and included in the “Technical Performance Requirements”	Yes this is correct. The current legal drafting allows for this process.	
		Yes we understand that there will be some extra cost for the equipment however Grid Forming is a critical next step to ensure GB grid stability as large synchronous machines are removed from the transmission system	We note this comment	
		However, to meet technical requirements for a Grid Forming converter, it is necessary to de-load a windfarm. In that case, a framework to compensate the loss in the revenue due to lost generation shall be established. For HVDC connected windfarms specifically this solution would need additional components and equipment offshore to provide the service. Energy storage at onshore HVDC (GBGF-I) may be needed to provide inertial power, although VSMOH (limited Inertia+Damping power; high Band Width requirements) are not precluded in Grid Code. Cost benefit in HPP may be better.	The purpose of the GC0137 Grid Code modification is to define a minimum technical specification. We have tried to achieve this is the most flexible way so that it can be integrated into a future short term stability market. The stability market will be addressed via a separate workgroup but it should be designed in such a way that the developer is able to submit its price taking into account the lost revenue from de-loading. We note this comment. As noted above the issue of storage fitted to an OFTO is an issue outside of this workgroup	
		Is it necessary to provide all the “Technical Performance Requirements”? Can some services eg phase jump, damping, vector shift control be provided as separate services, and you are paid for what you provide?	As noted the development of the market is outside the remit of this group and how these are procured on an individual or collective basis if an issue to be picked up by that group.	

		We think it should have its own standalone section where it is clear that it is non-mandatory to avoid confusion.	We note this point. We would however state that we have had a number of responses on this question and there is a slight bias towards including the text in the existing sections of the Grid Code.	
		How would the GBGF Grid Code be adapted to be included in the Network Restoration codes for the blackstart capability option (relaxations due to wind power fluctuations, eg for pumped hydro)?	This is not relevant. The EU Emergency Restoration Code makes no reference to Grid Forming. The first phase of the Emergency and Restoration Code was implemented into the Grid Code in 2019 and the second stage will be implemented in 2022. It is expected that the Black Start contract will generally state any relaxations permitted for reductions in wind or pumped hydro.	
		Will the definition of GBGF be the same in the context of blackstart, or instead, for example is Grid Leading behaviour preferred in the initial energization stage?	This has not been considered as yet but initially would be considered to be the same. This is something that could be considered as part of the Best Practice Guide.	
		In islanded operation, given that external grid is absent or weak, and may not have traditional PfQV coupling, so maybe that VSM based GF methods are not the best. Is this within scope of Grid Code? What rules apply in Grid Forming controls, since inertial response may not be the best approach in this instance, and may need to be adapted?	This issue is technically outside of this Grid Code modification. It is however something which could be considered as part of the GB Grid Forming Best Practice Guide.	
SGRE	Supportive  The requirements could be mandatory in future, but unlikely could ever be retrospectively applied  The implementation costs are not deemed to be excessive due to this proposal, but the grid forming properties will have cost(s) associated with them.	Many detailed comments have been provided in document ref “SGRE Response to GC0137 Consultation on Minimum Specification Required for Provision of GB Grid Forming (GBGF) Capability” – dated 30/04/2021	A separate document has been prepared in response to these detailed comments	Legal text to be updated

