

Webinar: HVDC Replicas Explained: What? Why? When? Where? How?

Date and time: 19/11/2024 12:00-13:00

Q	Is the provision of a replica already mandatory in the UK Grid Code, in the Bilateral Connection Agreement, or is it planned to be standardised to be mandatory in the future?
A	It is mandatory if it is included in a bilateral agreement but only if that is done by the TO or NESO. There's nothing stopping the developer pre-empting that need by including the requirement in their contract with the OEM, as having the replica benefits project delivery, its testing, commissioning and updating.
Q	Is a replica mandatory for all projects/stations? Or with one replica we can test for multiple projects?
A	In GB, Grid Code PC.A.4.5 enables NESO and/or the host transmission owner to identify the requirement for replicas in bilateral contracts. This is expected to grow over time, but there many ways to address this. In principle non project specific "reconfigurable" replicas can be developed. Different vendor approaches will have differing capabilities. The approach where used is to take new project settings and associated measurement differences and upload as software rather than physical change. As the question infers, less kit needed. Conversely, you can only model it as one thing at once. No one is doing this with hardware at present.
Q	How much cost will be added if asked for replicas from OEM?
A	A predictable answer – it depends on the type of replica. With software in the loop the limited hardware need means you are not covering a lot of physical cost, and the maintenance of code is something the OEM is already doing. Arguably the presence of the replica is also helping the generation of updates to offline models that will be required also.
Q	By using replicas, would you have a cost order of magnitude in terms of savings either by derisking or early testing before we go into commissioning?
A	Yes, the OEM has more time available to develop, test and refine code, which can be going on in parallel with C&P cubicles being delivered to site. You can test interfaces with other control and protection and other devices on the AC system, testing updates and investigating real world behaviour. It is significantly improving your control of a project.
Q	Do you see standards emerging for replica connections (interfaces)? Bandwidth, comm protocols, ...
A	RTDS is the real-time simulation platform used by all the main HVDC vendors, so it provides a common set of interfaces. Each vendor has their own systems, protocols, etc. and getting them to work together is the subject of various initiatives on "interoperability". I would also raise your question with a question. If you can represent the effect of a given set of communication systems and protocols with replicas in real time, is standardisation necessary? You can represent what a vendor is doing and account for it. It may be desirable to do more, but it's not essential.
Q	Are there any requirements for replicas of BESS, FACTS, or hydrogen electrolyser for co-development along with HVDC offshore interlinks that are being envisaged in upcoming future?
A	Yes, the value of replicas and real time simulation applies to all technologies, not just HVDC. At the Centre we have real time replicas of other devices also.

Q	Do the replicas have an expiry date? Is there any experience with issues when software developers have updated their software packages, e.g. PSCAD updates? Do study replicas cope OK with that?
A	Replicas are expected to last for as long as the project they represent. A hardware replica will be valid if the site physical equipment remains the same, as long as the software/ firmware is kept up to date. The real project control and protection will probably have an expiry date around 20-25 years. Another advantage of the replica is you have a version of what you originally did, which can aid asset replacement. The replica we host of the Moyle interconnector at the Centre is an example of a replacement control system.
Q	How do you manage cybersecurity in replica cubicles, given the hardware limitations and significant differences in the number and type of equipment compared to the project site cubicles for such cases? Firmware upgrades and licensing upgrades?
A	Cybersecurity is a big factor in the design of our replica hosting environment. A main feature is that the replicas are not connected to the internet. We operate separate domains for replicas and real-time simulation. Firmware upgrades and licensing will normally be managed by people coming to the Centre, or we can support some upgrades ourselves through a carefully managed process.
Q	Are replica panels a duplication/typical of actual project panels or will it be optimized/customized for testing requirement?
A	It is critical you are representing actual behaviour, not idealising it or over-simplifying it or modifying it to "pass a test". You are using it to understand the consequence of a developed (or developing) device to be connected to a system, using the insight of the replica to support operation and where appropriate OEM dialogue around new or modified functions.
Q	In one project there may be five stations. Do we need a replica for each station?
A	Yes, if modelling something with five terminals and you want to replicate and manage the control systems between them, you will need replicas for all and the associated multi-terminal control. You can of course mix approaches; you may conclude you have no need for that all to be done in a physical replica. It depends on what you are using it for.
Q	How detailed is the replica system, does it only have electrical protection and control functions or also consider non-electrical inputs like fire trip, non-electric trips from converter transformers, mechanical failures in valve cooling system, power de-rating due to low heat exchange, capacity of valve cooling, to name the few?
A	Normally the focus is on the control and protection that determines overall power system behaviour and performance. A "maintenance replica" will be closer to real-life with more of the hardware, e.g. covering fail-over systems for redundancy, but it is unlikely to cover all auxiliary systems found in the converter station.
Q	How does this work at the edges of your test networks? i.e. How do you model the behaviour of the AC grid? Thinking about grid impedance and controllers deeper into the AC network, is that important?
A	AC system modelling is very important and can be done to varying degrees according to need. But the requirement for real-time simulation does impose some practical limits on how big the models can be. It helps to have a substantial real-time simulation capability, as we do at the HVDC Centre.
Q	What is the accuracy of replicas with respect to the actual system? What tests are performed to validate this aspect?
A	In terms of the main control and protection functions, the replica is the same as the real system. But the models used in the real-time simulator that go around the replica should be tested and validated similar to other power system models.

Q	Are replicas currently used to validate real-time models against field tests or only to verify different component functionalities and their integration?
A	Yes, we have done a few comparison studies using the study replica based on the events that occurred on site.

Q	How will you approach a test routine involving all the 20 planned replicas to be hosted at the Centre? For sure it is possible to connect them all in one environment, but running all the possible operational scenarios with different parameters and system conditions is surely going to be impossible?
A	There will be limits to what is practical but it will be a matter of designing test processes according to what is required. There will be a combination of some tests done with each replica on its own, and others done with multiple replicas together.

Q	Do you typically have an automated process/testbed for testing and recording the real-time function and behaviour of the hardware under test, or is it necessarily a manual process of executing test cases and recording the results? If the latter, does that process practically scale to performing wide parameter scans, for example?
A	Automation is possible. As tests are being done in real-time the practice of testing is quite fast. As with all simulation the time preparing models and post-processing the results is critical. As with other EMT analysis, real-time tests are influenced by many variables and assumptions influencing the operating point of the device under test and the test conditions, so build up in "baby steps" is advisable. Start mimicking FAT and reference studies, and then grow the complexity of the test environment and tests conducted.

Q	Is there any plan to have a replica of whole HVDC projects, to check the overall dynamic performance of UK HVDC systems, and their interactions? Will this be a generic model, or using a black box model from the HVDC manufacturer?
A	We have a number of replicas at the Centre and are expanding the scale and capability to accommodate the around 30 or so replicas expected to support the GB system in 2030. These are mostly hardware replicas, however, increasingly the capability of software-based replicas offers new options for a broad range of technologies to be represented accurately in real-time. Dynamic testing is very much a focus, representing the real behaviour of the technology across transient, small signal interactions, etc. One of the benefits of replicas is you are representing all of the relevant device code for control and protection. There is no need to convert it when updated, just a need to upload it to the replica. This allows you to "dry run" device performance when new features are switched on, and hence track changes and respond quickly to any need to investigate real-world behaviour.

Q	When you receive the cubicles of different vendors for one project, how do you integrate them into one project? How long does it usually take? Do you set requirements with vendors beforehand for easier integration?
A	Each project is normally supplied by one vendor, but there is a growing level of activity on interoperability. Please see our website for a recent webinar on this topic. Specifying clear requirements is critical to achieving effective integration.

Q	Replica panels should be delivered along with project panels or they should be delivered earlier so that experts test at the National HVDC Centre and implement test cases in actual project panels during commissioning?
A	Can be done either way. Typically, the replica panels will be used for factory testing and might be retained at the vendor factory through project commissioning then moved to their permanent home. Or if a project is built in stages, as was done with CMS, then the replica may be used for testing ahead of construction and commissioning of later parts of the project.