## CASE STUDY: DE-RISKING HVDC

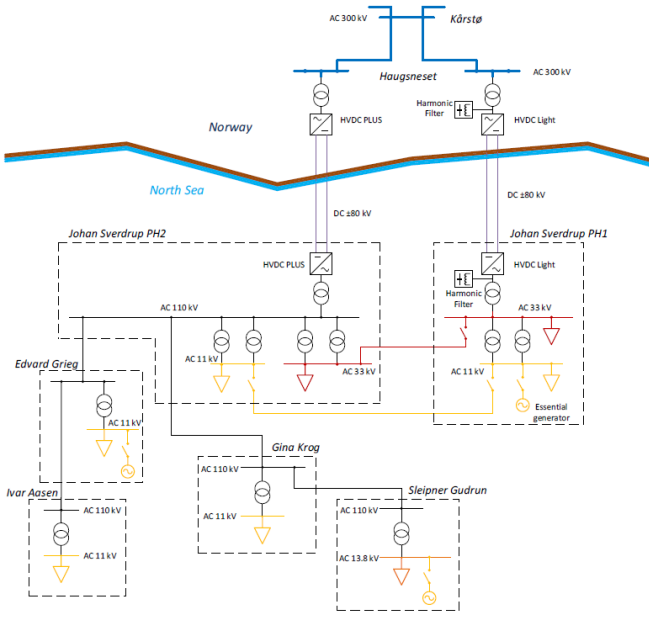
# ENSURING INTEROPERABILITY FOR MULTI-VENDOR HVDC VIA REPLICA TESTING

## USER PROFILE: RTE INTERNATIONAL LENDS EXPERTISE TO A MILESTONE HVDC PROJECT IN NORWAY

The Johan Sverdrup project, owned and operated by Equinor, is the world's first multi-vendor HVDC scheme feeding an islanded offshore AC power system. The project consists of five oil and gas platforms, located on the Norwegian continental shelf, fed by two parallel HVDC links from different manufacturers. The first VSC-HVDC link, commissioned in 2018, was supplied by Hitachi Energy. The addition of a second MMC-HVDC link, supplied by Siemens, completed the project, but introduced challenges – both technical and relating to vendor confidentiality requirements.

Equinor called on **RTE International**, a subsidiary of Europe's largest TSO, to lend their expertise to the project. RTE International provides consulting and engineering services, strengthened by their unique experience with multi-vendor / multi-infeed HVDC systems and real-time simulation.

**Involvement of a third party with real-time simulation expertise facilitated HIL testing to ensure interoperability of both vendors' controls while protecting IP.**




*Single line diagram of the Johan Sverdrup project*
*Image courtesy of Equinor*

## PROJECT FOCUS: HARDWARE-IN-THE-LOOP TESTING TO DE-RISK AGAINST INTERACTIONS

As a two-phase multi-vendor project, Johan Sverdrup presented unique technical challenges. The two HVDC systems were developed with limited knowledge about each other, and adverse interactions between the two links were likely to occur. To address this risk, Equinor chose to include **control and protection replica hardware** in the project. These replicas were delivered to RTE International's lab and connected to a network simulated on the **RTDS Simulator®** for **hardware-in-the-loop** (HIL) testing to ensure secure operation of the scheme under all operating conditions.

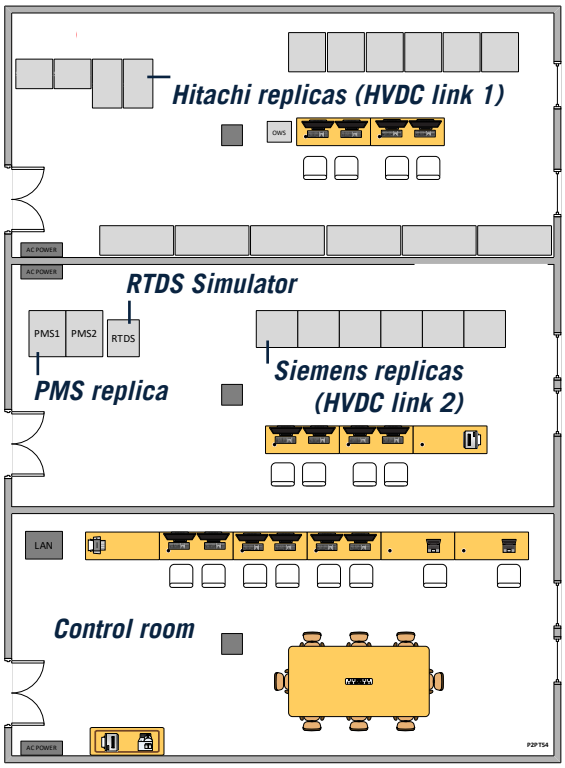
*The RTDS Simulator connected to the PMS in RTE International's lab*
*Image courtesy of RTE International*

Additionally, to facilitate interoperability of the two HVDC links and stable control of the entire Johan Sverdrup power network, a Power Dispatch Control System was developed by Kongsberg Maritime Technologies. This control system includes a Power Management System (PMS), which is responsible for secondary load sharing between the HVDC links relative to their available capacity, among other functions. A replica of the PMS was also included in the HIL testbed. The ability to test the hardware with the RTDS Simulator was valuable, as no detailed offline simulation model for the PMS was available.

**Testing the replica Power Management System, developed for high-level coordination of the two HVDC links, was a key aspect of the de-risking and validation process prior to commissioning the second link.**

## MODELLING AND TESTING: A SPECIAL REPLICA TESTING FACILITY TO SUPPORT COMMISSIONING

The control and protection replicas from Hitachi Energy (phase 1 link), Siemens (phase 2 link), and Kongsberg (PMS) were housed in RTE International's real-time simulation laboratory. The Hitachi and Siemens replicas were installed in separate rooms with secured access, with a third room dedicated to control.




*Laboratory layout for the Johan Sverdrup project's control and protection replicas*

*Image courtesy of RTE International*

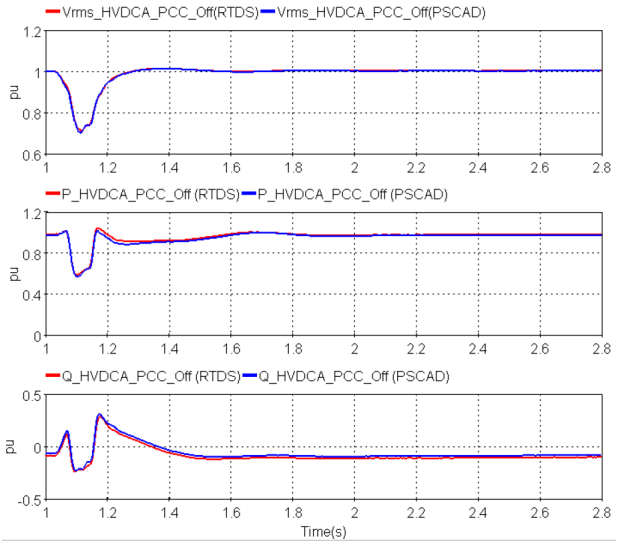
The following events were studied:

- Power sharing between the two HVDC links
- Energization of all HVDC converters and offshore loads
- Load shedding and rejection
- Synchronization of offshore HVDC converters
- Fault ride-through for symmetrical and unsymmetrical fault conditions, both on- and offshore

**Commissioning tests** were executed for both HVDC links using the replica controls, including verification of modifications to the original link to accommodate parallel operation with the new link. Standalone operation of each link was tested, as well as verification of each link's interface to the PMS.

Parallel operation was then tested, in which both replicas were simultaneously connected to the RTDS Simulator, including:

- Synchronization of HVDC links via only primary droop control
- Synchronization of HVDC links via PMS
- Individual tripping of each link during parallel operation
- Parallel operation alongside essential offshore gas generator
- Soft disconnection of both HVDC links via 33 kV cable interconnecting offshore inverters




*Comparing results from offline simulation to HIL setup for a single-phase onshore fault*

*Image courtesy of RTE International*

## OUTCOMES: DEPLOYING WITH CONFIDENCE

For the Johan Sverdrup project, both offline and real-time EMT simulation were used throughout the project timeline. Benchmarking the results from HIL testing of the replicas against an offline simulation containing the vendor control models was an important part of validation - and results matched very well.

**HIL testing with vendor control replicas led to modifications in both the HVDC and PMS controls, which improved the overall dynamic performance of the Johan Sverdrup project.**

Replica testing provides unique insights into interactions and misoperations which may otherwise be difficult to identify, making it a key part of the study and testing process for HVDC projects. To **reduce risk and increase confidence** in the secure parallel operation of the Johan Sverdrup project, the RTDS Simulator was critical.

***LEARN MORE ABOUT HIL TESTING FOR HVDC & FACTS SCHEMES AT RTDS.COM/APPLICATIONS***

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