vårgrønn

Annex 01: Supporting Rationale for Proposed SQSS Amendment

1. Purpose of the Attachment

This attachment provides the technical, economic and operational rationale for amending the NETS SQSS offshore AC transformer redundancy provisions. It expands on the concise responses in the NESO template and sets out the evidence supporting Vårgrønn's proposal to enable compliant deployment of lower-cost offshore AC transmission configurations.

2. Summary

Vårgrønn has assessed a range of offshore transmission concepts to identify lower-cost solutions for exporting offshore wind power to shore. Several of the configurations under consideration use simplified offshore electrical arrangements, including designs that reduce the number of offshore transformers. Under the current NETS SQSS provisions, such configurations are restricted for offshore grid entry point capacities of 90 MW or more, which may limit the adoption of otherwise standard and cost-efficient offshore wind farm designs.

As part of this optimization work, Vårgrønn has evaluated simplified offshore AC substation configurations, focusing on the standard single-export-circuit platform topology as a representative case. Our assessment indicates that reducing the number of offshore transformers can deliver significant material cost efficiencies through reductions in platform size, fabrication effort, structural weight and long-term operational expenditure. These efficiencies directly reduce LCOE by lowering both upfront capital requirements and ongoing OPEX.
The principles established through NESO modification proposal GSR034—although developed for offshore DC converter stations—are closely aligned with our findings. GSR034 supports offshore transmission designs with reduced equipment redundancy where justified by analysis, and its conclusions are consistent with our assessment that simplified offshore AC configurations can deliver material cost and environmental benefits while remaining operationally manageable.

In light of the direction set by GSR034, Vårgrønn considers that a review and amendment of the relevant NETS SQSS provisions is required to enable compliant deployment of lower-cost offshore AC transmission configurations

3. Background

The current NETS SQSS requirement for offshore AC connections above 90 MW limits the loss of a single offshore transformer to no more than 50% of the offshore grid entry point capacity. In practice, this threshold becomes the binding constraint and prevents the use of simplified offshore AC configurations that employ a single transformer, even where the resulting infeed loss remains well within the normal infeed loss risk and where such designs are technically robust and widely used internationally.

This requirement reflects traditional onshore design philosophies, where equipment redundancy can be provided at relatively low cost and without major structural implications. Offshore substations face fundamentally different constraints: platform structures dominate both capital cost and embodied carbon, and installation activities carry materially higher risk and expense. As a result, prescriptive redundancy rules can drive disproportionate increases in platform size, steel tonnage, installation complexity and long-term operational expenditure.

Industry experience, supported by long-running CIGRE transformer reliability studies, shows that major transformer failures are rare and that offshore units exhibit similar reliability characteristics to onshore units. Given that the normal infeed loss risk applicable to the wider transmission system is significantly higher (currently 1320 MW), the loss of a single offshore transformer is well within system capability. This indicates that the 50% threshold is an offshore-specific constraint rather than a system security necessity.

4. Technical and Operational Assessment

Industry experience, including long-running CIGRE transformer reliability studies, shows that major transformer failures are rare and that offshore units exhibit reliability characteristics comparable to onshore installations. This evidence indicates that mandatory offshore transformer redundancy may not be proportionate to the underlying failure risk.

From a system security perspective, the loss of a single offshore transformer remains well within the normal infeed loss risk applicable to the wider transmission system, currently 1320 MW. This demonstrates that the existing 50% offshore-specific threshold is not driven by system capability but is instead a design constraint unique to offshore AC connections.

Offshore substations also face fundamentally different engineering and operational conditions compared with onshore sites. Platform structures dominate both capital cost and embodied carbon, and installation activities carry materially higher risk and expense. Prescriptive redundancy requirements therefore have a much greater impact offshore, driving increases in platform size, steel tonnage, installation vessel requirements and long-term operational effort.

Operationally, simplified offshore AC configurations remain fully manageable. Reducing the number of transformers decreases the volume of equipment requiring commissioning, inspection and maintenance. This directly reduces offshore interventions, vessel transfers and time spent on the substation, improving operational efficiency and lowering exposure to offshore working environments. These characteristics are consistent with established international practice, where single-transformer offshore AC platforms are widely deployed without compromising operational performance.

5. Economic, Environmental and HSE Implications

The structures required to support offshore transmission equipment represent the largest proportion of offshore substation capital cost, and they also account for most of the associated embodied carbon and CO_2 footprint. Requirements that increase platform size or structural complexity therefore have a direct and material impact on both project economics and environmental performance. Designs that mandate multiple offshore transformers drive larger topside dimensions, higher steel tonnage, more complex fabrication and heavier installation requirements, all of which increase cost and CO_2 emissions without delivering proportional system security benefits.

Simplifying the offshore AC configuration by reducing the number of transformers enables a smaller and lighter platform. This reduces fabrication effort, lowers steel consumption, and decreases installation vessel time and complexity. These effects translate into meaningful reductions in both CAPEX and OPEX, and therefore directly reduce LCOE. The benefits are particularly significant in the current market environment, where offshore construction costs and supply chain pressures are major contributors to project viability challenges.

The carbon implications follow the same pattern. A smaller platform with fewer heavy components results in lower embodied carbon and CO_2 footprint, while reduced installation and maintenance activity further decreases emissions associated with vessel operations. These reductions support wider system affordability and contribute to the efficient delivery of offshore wind capacity in line with net-zero objectives.

There are also clear HSE advantages. Transformer commissioning and maintenance require multiple vessel transfers and extended time on the offshore substation. Reducing the number of transformers directly reduces the frequency and duration of offshore interventions, lowering personnel exposure to vessel operations and offshore working environments. This improves the overall risk profile without compromising operational performance.

6. Alignment with GSR034

NESO’s recent assessment under modification proposal GSR034 is directly relevant to the issues encountered with offshore AC transformer redundancy. Although GSR034 focused on offshore DC converter stations, it examined whether existing SQSS loss-of-infeed requirements remain appropriate for modern offshore transmission designs. The analysis concluded that prescriptive, equipment-based redundancy rules can lead to disproportionate cost and carbon impacts, and that system security can instead be maintained through a risk-based assessment of credible infeed loss events.

The SQSS Panel unanimously supported this principle. GSR034 therefore establishes a clear direction of travel: offshore transmission design should not be constrained by rigid redundancy requirements where system security can be demonstrated through analysis. This approach recognizes that offshore infrastructure carries fundamentally different cost, carbon and installation implications compared with onshore substations.

While GSR034 relates specifically to DC technology, the underlying rationale applies equally to offshore AC substations. The same issues arise: platform structures dominate cost and embodied carbon, installation activities are complex and high-risk, and the normal infeed loss risk of the wider system is significantly higher than the loss associated with a single offshore transformer. The principles endorsed through GSR034 therefore support a more flexible, risk-based approach to offshore AC design, enabling simplified configurations where they are technically justified and operationally manageable.

7. Conclusion

The current SQSS offshore AC transformer redundancy requirement imposes disproportionate cost, carbon and operational impacts without delivering commensurate system security benefits. Simplified offshore AC substation configurations are technically robust, operationally manageable and widely deployed internationally, and the loss of a single offshore transformer remains well within the normal infeed loss risk of the wider transmission system. The evidence shows that prescriptive redundancy rules drive unnecessary increases in platform size, steel tonnage, installation complexity and offshore working hours, with direct consequences for project viability, embodied carbon and personnel safety.

The principles established through GSR034 demonstrate clear industry support for a more flexible, risk-based approach to offshore transmission design. Extending this approach to offshore AC connections would enable the deployment of cost-efficient and lower-carbon configurations while maintaining system security. Vårgrønn therefore considers that a review and amendment of the relevant SQSS provisions is necessary to ensure that offshore AC transmission design reflects modern practice, supports efficient delivery of offshore wind and contributes to wider system affordability and net-zero objectives.