

SONI Grid Code Proposed Minimum Generation Studies Executive Summary Report

External Studies Support resulting from proposed Modification to
CC.S1.1.3.8 and CC.S1.2.3.3 of the SONI Grid Code





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Executive summary

EP Kilroot, (a subsidiary of EP UK Investments), proposed an update to the SONI Grid Code Clauses CC.S1.1.3.8 and CC.S1.2.3.3 to modify the minimum generation (min gen) requirements for generation units in Northern Ireland (NI).

	Current	Proposed
CC.S 1.1.3.8 (CC.S1.2.3.3)	A generating Unit must be capable of remaining Synchronised to the NI System at an Output which is no greater than the lower of 80MW or 40% of its maximum continuous rating.	A generating Unit must be capable of remaining Synchronised to the NI System at an Output which is 40% of its maximum continuous rating

Jacobs has been contracted by SONI to provide support for the evaluation of the proposed Grid Code modification, and to help SONI gain a comprehensive understanding of the potential and impacts of modifying the Grid Code's min gen requirements.

Phase 1 of the assessment focused on investigating the proposed modification of the min gen requirements through comprehensive market research studies. This phase involved evaluating the requirements outlined in the Industrial Emissions Directive (IED) and Best Available Techniques (BAT), as well as examining the SONI Grid Code (specifically applicable to generators). Additionally, best practices from various Transmission System Operators (TSOs) and the technological capabilities of generator Original Equipment Manufacturers (OEMs) regarding min gen requirements were analysed.

In Phase 2 of the assessment, the focus shifted to analysing the system's net cost-benefit and the potential market impact of changing the min gen requirements. This analysis was conducted using techno-economic studies in PLEXOS, a tool for assessing the technical and economic aspects of power systems. Furthermore, the assessment considered the environmental impact of the proposed changes by analysing the system's emission levels.

This executive summary report provides an overview of the assessment's findings, incorporating the combined research from Phase 1 and Phase 2. The report assesses the suitability of the proposed min gen requirement and evaluates the overall impact of modifying these requirements in relation to the research undertaken.

Overall Summary

According to market research, the TSOs Grid Codes min gen requirements settings can be modified based on the specific needs of the electrical network, particularly to accommodate new connections and the increasing integration of renewable energy sources. However, it is crucial for the TSOs to consider the network's ability to handle fluctuations in generation and demand, ensuring the power system's security and stability. This consideration encompasses maintaining sufficient levels of inertia, which is essential for reliable power system operation.

The analysis of four TSOs, including SONI, suggests that min gen requirements may be modified based on the following observations:

- The historical changes in Finland show that the min gen levels for hydropower, combined cycle gas turbines (CCGTs), motor power plants, and combined heat and power plants were updated in 2013. These updates considered technological advancements that expanded the safe operating range of generation units, making it possible to decrease the min gen threshold to 10%.
- The research of Portugal showed that the TSO adopted the min gen criteria similarly by considering the capabilities of generation-turbine systems, as well as factors such as service quality, reliability, and network security. Consequently, Portugal implemented a min gen requirement of 40%.

- In contrast, the UK have implemented two different min gen levels, namely 65% and 55%. This dual approach allows for increased flexibility in regulating frequency during fluctuations in demand or generation, while also providing a safety margin for the operation of generator-turbines.

Based on the research findings, it is suggested that the min gen requirements can be modified. This is supported by the fact that some TSOs have already updated their min gen requirements to align with the evolving system needs and advancements in turbine capabilities.

However, the TSO (Grid Code's min gen requirements) may also need to consider the design limitation and capabilities of standard generator OEMs to comply with all the Grid Code requirements, the IED and the impact of other regulations across the entire loading range specified in the Grid Code. The IED evaluation has shown the following:

- To operate legally, a generator needs to obtain an appropriate permit from the relevant environmental regulator which is the Northern Ireland Environment Agency (NIEA) in Northern Ireland. This permit would include compliance with emission limit requirements set out in the IED and BAT documents.
- To obtain the permit the NIEA would also assess the overall efficiency (at the rated power) against the BAT requirements.
- The BAT emission limits requirements can be interpreted in two ways depending on the country of application. Each country can interpret the compliance with the BAT emission limits as either applied to the load range above 70%, as is the case in Finland, or to the full load range. The NIEA interprets the BAT emission limits as applied to the entire feasible generator-turbine operating load range specified in the Grid Code.
- There is no limit prescribed within the IED or BAT around the minimum or maximum load on a generator. The min gen is only addressed in the Grid Code.

This assessment considered the capabilities of three of the top global utility gas turbine OEMs: Siemens Energy, General Electric (GE), and Mitsubishi Power. The assessment utilized data gathered during market research phase. The initial project scope considered assessment of a broad range of turbine technologies and sizes. However, due to project time constraints the assessment focused on the utility gas/steam turbines only. It also focused on the 200-500MW power rating range since this range is affected by the proposed modifications to the min gen clauses. Furthermore, the OEMs' minimum emission compliant generation capability is obtained with respect to the full generator-turbine operating load range specified in the Grid Code, as required by the NIEA. The assessment found that:

- Siemens turbines can operate with a min gen of 40% for Open Cycle Gas Turbine (OCGT) applications and 45% for CCGT applications, within the emissions compliant load range. The OCGT can also operate with a reduced min gen of 35% using mitigation techniques such as Selective Catalytic Reduction (SCR)
- Mitsubishi turbines can operate at a min gen of 50% without, or possibly as low as 40% with mitigation techniques respectively.
- GE turbines can operate with a min gen of 30% - 35% for OCGTs and for CCGT applications, the min gen range is 40% - 48%.
- The OEMs' emissions compliant min gen levels mostly align with the min gen requirements in the three TSO countries National Grid in UK, REN in Portugal, and SONI in NI. The only exception is the Finnish grid in Finland where the 10% min gen requirement is significantly lower than the OEMs' emission compliant load levels. The reason for this could be that Finland interprets compliance with the BAT emission limits requirements only for the load range above 70% and based on OEM research the turbines can comply with such requirements. For the 10% to 70% load range, it is possible that other domestic criteria apply. This means that although the 10% min gen requirement considers safety of turbines' operation, it may not consider the BAT emission limit compliance.

As part of the min gen research, techno-economic studies have been conducted in PLEXOS. This considered the net cost-benefit and the market impact of changing the min gen requirements. The studies evaluated the impact of four min gen sensitivities, 35%, 40%, 45% and 50% for years 2027 and 2030, with respect to the existing min gen requirements as the reference scenario (lesser of 40% rating or 80MW).

PLEXOS studies showed that under all min gen sensitivities across 2027 and 2030, except for the 35% sensitivity in 2027, implementing the rule change results in an increase in the net cost to the Irish Single Electricity Market (SEM) with respect to the existing reference scenario. In 2027 the increase in cost relative to the reference scenario ranges from €13.7M under the 40% sensitivity up to €56.2M under the 50% sensitivity. In 2030 the cost ranges from €14.7M under the 35% sensitivity up to €33.2M under the 50% sensitivity. The studies also showed that the net system cost increases as the min gen setting increases. Further studies showed that the main source of the cost increases can be attributed to the increases in fuel and emission costs, and this is mostly sourced from the gas-fired generating units in Northern Ireland.

The PLEXOS modelling results have shown that a lower min gen requirement is better from a cost-benefit and emissions impact perspective. This implies that having a lower min gen requirement is more beneficial from both an environmental and market standpoint. A lower min gen requirement implements a more flexible power system that burns less fuel, produces less emissions and curtails less low-cost renewable power.

Assessment Findings

The analysis carried out indicates that the proposed modification, i.e., removal of the 80MW min gen limit, from the NI Grid Code clauses CC.S 1.1.3.8 and CC.S.1.2.3.3 does not pose significant obstacles. The assessment also indicates that the proposed modification is suitable based on evaluating requirements of four TSOs (including SONI), historical system changes, IED/BAT and Environmental Agencies' requirements (particularly NIEA in the NI system), and the capabilities of the generation-turbines. Also, the feedback received from generator OEMs suggests that there are no major obstacles in complying with other NI Grid Code clauses that could be affected by the proposed change in min gen requirements.

The assessment has highlighted the importance of considering the following observations/conclusions:

- The assessment has indicated that utility-scale turbines within the power rating range of 200-500MW can effectively operate with
 - min gen criteria of 40% for OCGT applications and 45%-50% for CCGT applications, without the need for any mitigation techniques.
 - with min gen criteria of 35% for OCGT applications and 40% for CCGT applications, with the application of the mitigation techniques.
- Increasing the min gen criteria above the proposed settings; results from PLEXOS analysis show that this would result in the net system cost increase to the Northern Ireland electricity market and the increase in the system emissions' levels. Also, it would reduce the ability of the electrical network to deal with the emerging issue of managing the minimum demand conditions.
- To meet the 40% min gen setting or a more stringent setting, the generator-turbines OEMs may need to apply the mitigation techniques (especially for CCGT plants). Based on Jacobs' experience, implementing such measures may bring some economic challenges for generators.
- The adoption of alternative min gen clause settings may be suggested based on the requirements of the system needs in the electrical network, as well as the assessment of risks, benefits, and other factors such as techno-economic considerations and market impacts.
- The NIEA plays a crucial role in prescribing the emission level constraints, as interpreted from BAT, which affects the min gen capability of generator units in Northern Ireland.

Study risks and limitations

This study was conducted using a variety of sources of information. Some OEMs were only able to provide high-level information, so the final min gen conclusions should be treated with some caution. Also, the OEMs cannot guarantee the min gen figures provided with reference to the use of the mitigation techniques. Further project by project basis studies must be conducted to confirm actual achievable min gen with mitigation techniques. This study also did not consider operators' business case, socio-economic effects, whole NI system pollution & environmental impact and any other regulatory aspects except one mentioned in the report on the min gen requirements. Additionally, the min gen assessment is based on a limited set of turbine technologies and power ranges (200-500MW), so it may not be representative of all turbines or OEMs. It is important to note that existing turbines below 200MW are not expected to be affected by the proposed min gen criteria of 40%.