# Larne Main Transformer Upgrade

## Needs Report

October 2023

SONI

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# 2 Summary

There are two 110/33kV transformers at Larne Main Substation which are rated at 45MVA each. Currently the substation is N-1 secure and capable of maintaining normal operations in the event of the unplanned loss of the second transformer. But due to future proposed generation and demand forecasts the 45 MVA rating will be insufficient. In the event of the unplanned loss of a transformer, the remaining in-service unit would be at risk of overloading if additional capacity is not provided.

This report summarises the need to increase the total transformer MVA capacity/rating at Larne main substation.

# 3 Introduction

To comply with the 80% renewable energy target for 2030 set by the executive in Northern Ireland along with The Climate Change Act (Northern Ireland) 2022, the level of renewable generation connected in the Northern Ireland is expected to increase including at Larne Main.

The SONI Transmission Development Plan, Northern Ireland (TDPNI) 2023-2032 makes provisions for the reinforcement required for the 2030 Energy Strategy target. This project is included in this document named as "Larne Main Transformer Replacement".

An overhead image of Larne Main substation is shown in Figure 2 below.

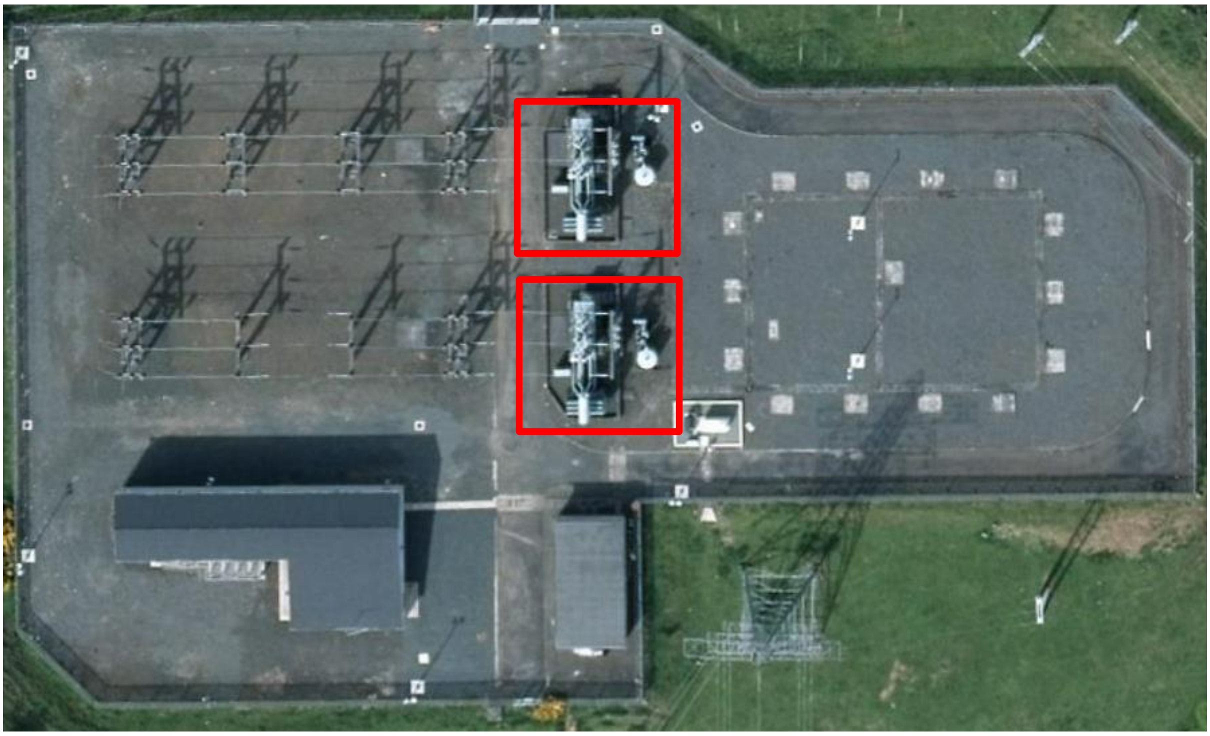

Figure 1 - Overhead image of Larne Substation (Taken from Spatial NI)

Currently there are three large scale wind farms connected on the 33 kV side of Larne Main substation as listed in the table below along with their maximum export capacities:

Table 1 - Large Scale Wind Farms Connected at Larne Main

| **Large Scale Wind Farms** | **Maximum Export Capacity (MW)** |
|---|---|
| Wolf Bog | 10 |
| Elliot's Hill | 5 |
| Ballykeel | 16.1 |
| **Total** | **31.1** |

The table below shows the installed generation capacity connected at the Larne Substation, including both small-scale & large scale, along with proposed additional generation capacity, this data has been taken from the All-Island Ten-Year Transmission Forecast Statement (TYTFS) 2022.

**Table 2 - Installed Generation and Proposed Generation at Larne Main**

| Technology Type | Current Generation Capacity (MW) | Proposed Additional Generation Capacity (MW) | Totals |
|---|---|---|---|
| Large Scale Wind | 31.1 | 0 | 31.1 |
| Small Scale Wind | 9.7 | 0.2 | 9.9 |
| Small Scale Solar | 4 | <0.1 | 4.0 |
| Small Scale Biomass | 1.5 | 0 | 1.5 |
| Small Scale Hydro | 0.9 | 0 | 0.9 |
| Large Scale Battery | 0 | 20 MEC/ 20 MIC | 20 |
| Totals | 47.2 | 20.2 MEC | 67.4 |

The current Generation capacity connected at Larne is 47.2 MW. This is higher than the transformer capacity, which is limited to the rating of one transformer (45 MVA) ensuring the substation is N-1 secure and capable of maintaining normal operations in the event of the unplanned loss of the second transformer. The proposed large scale battery generation connected at 33 kV level, will operate in two modes, export and import. It has a maximum export capacity (MEC) of 20 MW and maximum import capacity (MIC) of 20 MW, meaning the total generation capacity (current and future) will range from 47.2 MW to 67.4 MW. The proposed additional generation will mean the generation capacity (47.2 to 67.4 MW range) will be significantly higher than the transformer capacity. When considering the demand profile at Larne Main Substation, the capacity at Larne is given by:

$$Capacity\ at\ Larne = Generation\ Capacity - Minimum\ Demand$$

The minimum demand is estimated at 12.7 MW. The Summer valley data taken from table 3, shows the capacity at Larne, based on current transformer rating, will be 34.66 MW (47.36 MW-12.7 MW=34.66 MW) MW or 36.48 MVA (assuming a worst-case scenario power factor of 0.95).

Therefore, it is possible for the generation connected at Larne to exceed 45 MVA/42.75 MW (assuming a worst-case scenario power factor of 0.95) without overloading the transformer, when considering the minimum demand at Larne that can absorb the generation locally. Therefore, Larne currently has a Generation headroom of 8.09 MW.

With the new 20 MW large scale battery fully exporting, the generation headroom becomes -11.91 MW and with the battery fully importing, it is 28.09 MW. However at this stage the operating regime of the battery is not fully known and cannot therefore by counted against the minimum demand for the pruposes of calculating capacity for generation.

Increased transformer capacity will enable further generation connections at the substation and full utilisation of the current and proposed generation.

**Table 3 – Larne Main Demand Data from TYTFS 2022**

| Bus Code | Bus Name | Power Factor | Demand Forecast (MW) – Winter Peak | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 |
| LAR | Larne | 0.99 | 42.2 | 43.4 | 43.5 | 44.3 | 45.9 | 46.7 | 47.6 | 48.6 | 49.6 | 50.8 |
| Bus Code | Bus Name | Power Factor | Demand Forecast (MW) – Summer Valley | | | | | | | | | |
| | | | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 |
| LAR | Larne | 0.99 | 12.4 | 12.7 | 12.8 | 13.0 | 13.4 | 13.7 | 13.3 | 12.9 | 12.4 | 14.9 |

The forecasted demand for Larne (Table 3) shows that the demand profile for winter peak is extremely close to the transformer rating and will exceed the rating by 2026. The proposed large-scale battery will mean that the demand at Larne will significantly increase at periods where the battery is importing and low renewable generation. This will mean that the transformer is at further risk of overloading.
EREC P2/8 and EREP 130/4 outline capacity credit for distribution generation showing a long-lasting outage significantly lowers the contribution from intermittent generation. For the failure of one transformer at Larne, with a lead time of two weeks for its replacement the distribution generation cannot be relied upon to meet the demand at Larne due to its variable nature. This could lead to the other transformer potentially overloading during this period.

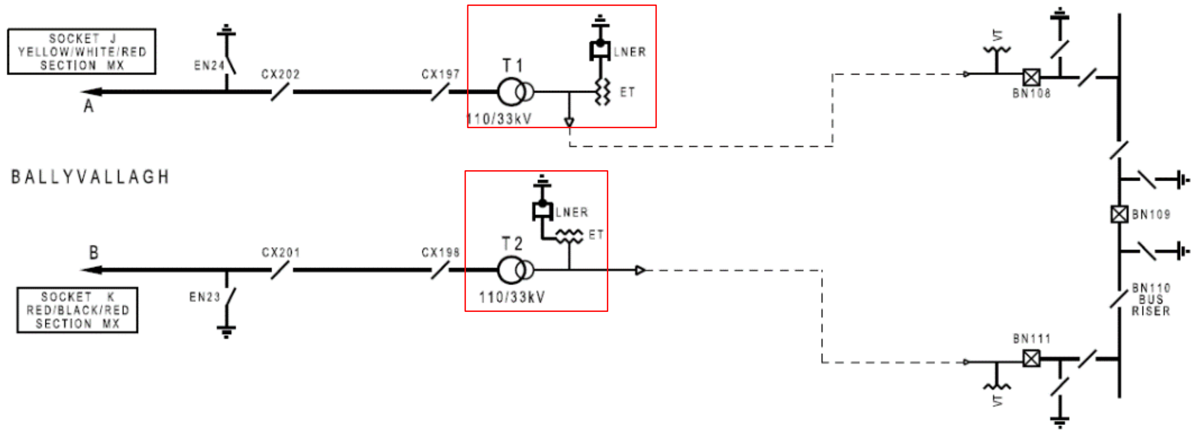


**Figure 2 - Single Line Diagram of Larne Main Substation (Transformers Highlighted)**

Using the transformer's cyclic overload rating for an 8-hour peak/16-hour half load profile would allow for the transformer to be safely overloaded up to +20% of the transformer nameplate rating. This policy is accepted by both NIEN and SONI but applies to transformers that are under 40 years old. Both transformers were manufactured in 1968 meaning its Cyclic Overload Rating can no longer be utilised and the nameplate rating limit applies. This is unacceptable as it means the substation would not be N-1 secure and capable of maintaining normal operations in the event of the unplanned loss of the second transformer. This would be a breach of the Transmission System Security and Planning Standards Security and Quality of Supply Standard (TSSPS).

# 4 Network Issues

Having installed generation capacity greater than the rating of the transformer minus the minimum demand would mean controllable renewable generators have to be constrained to resolve overload contingencies for an N-1 scenario on the transformers during period of low demand and high renewable generation. This would require creation of a new wind constraint group or creation of a new special protection scheme at Larne. However, this would not allow additional small scale generation connections, which are below the threshold for controllability or address the age of the transformers. By 2026 the forecasted winter peak demand will exceed the transformer rating which cannot be constrained and therefore the total transformer capacity rating at Larne main substation must be increased as the transformer cyclic overload ratings no longer apply, and nameplate ratings must be adhered to.

# 5 Conclusions

In conclusion, as the forecasted winter peak demand by 2025 and especially by 2026 will exceed the capacity of the transformer, the unplanned loss of one 110/33 kV transformer at Larne will cause overloads on the second transformer at low generation levels. Due to the limited generation capacity at Larne arising from the transformer ratings, there is very little capacity for additional large- and small-scale renewable generation to be connected at Larne Main substation without risking an overload of the transformers under a credible contingency. Increasing capacity here is also unlikely to be chargeable to any proposed generators as such a reinforcement can only be charged to a connecting customer if the need for reinforcement still exists when all other flows are ignored, which is not likely.

There are some options for what work can be carried out to address the issue, and these are discussed in the options report.