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400 kV GIS Development for Ireland

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SUMMARY

As the demand for energy increases, utilities are tasked to supply the energy efficiently at as low a cost as possible, but with the highest reliability.

To achieve lower cost for both manufacturer and utility, manufacturers have to decrease the size of equipment, which means a smaller footprint, but at the same time not giving up any of the features of the equipment. Also, due to very competitive markets, this has to be done in co-operation with the various suppliers and the utilities.

This paper describes the approach taken in the development and installation of new 400 kV GIS equipment in the existing Moneypoint 400 kV substation in Ireland.

Under the National Renewable Energy Action Plan (NREAP) the Irish government has committed to 40 % of electricity generated from renewable sources by 2020. EirGrid, the transmission system operator for Ireland, has established the Grid 25 programme to marry together this government target and the anticipated needs of existing and future Grid users. To date wind energy is the main source of renewable electricity generation in the country. The current total wind capacity is over 2,000 MW generated from over 190 wind farms, mainly consisting of windfarm clusters in the north-west and south-west of the island. The redevelopment of Moneypoint 400 kV GIS substation is the key gateway in delivering this wind generation from the south west of the country to the main load centres in the east of Ireland.

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The focus of this paper is to outline the development of this project and its timelines and the key technical issues unique to the Irish 400 kV system that had to be considered and managed in the selection of the switchgear.

The normal IEC BIL requirement for a 400 kV system is 1425 kV whereas calculation and experience have led to a policy of requiring a BIL of 1550 kV, a value normally associated with a 550 kV system, for equipment used on the Irish 400 kV system. The most straight-forward solution would have been to buy the normal 550 kV systems available on the market. This would have resulted in a higher cost and a much bigger footprint and also a substantially bigger building, so the specification was written to try to obtain 400 kV GIS with some additional performance requirements rather than the default alternative of 550 kV.

Aside from the BIL requirements, the specification also required that the Transient Recovery Voltage be in accordance with IEC62271-100 except for a first-pole-to-clear factor which is required to be 1.5 for all test duties.

KEYWORDS

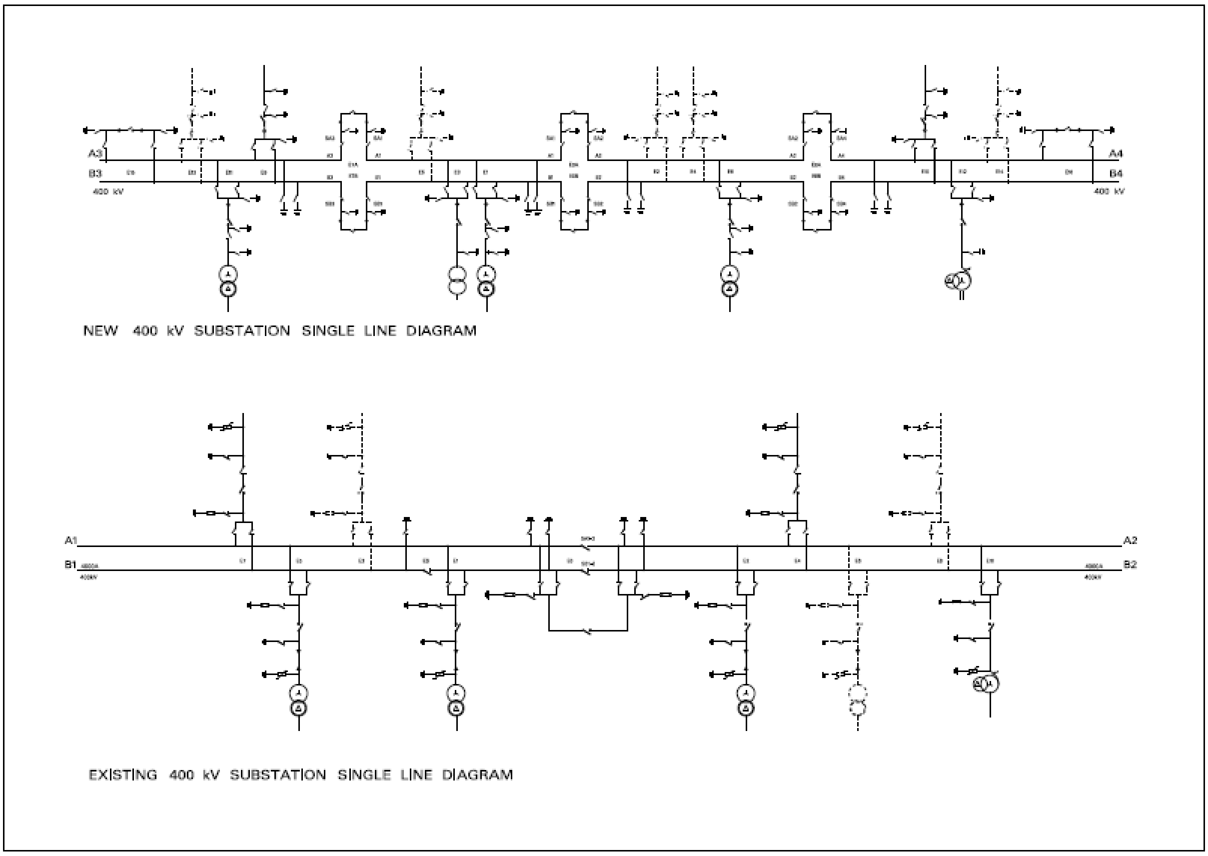
Gas Insulated Switchgear	(GIS)
Lightning Impulse Withstand voltage	(BIL)
Switching Impulse Withstand	(SIL)
Transient Recovery Voltage	(TRV)
Building layout	

INTRODUCTION

Moneypoint is the largest power station in Ireland. It was built in the 1980's and has a generating capacity of 900 MW. The power station is connected to Moneypoint 400 kV substation through three 330 MVA 17 kV / 400 kV step up transformers. The substation is then connected to the main load centre on the east coast by two 400 kV lines. The existing Moneypoint 400 kV substation is being redeveloped to cater for the large increase of wind generation which is primarily located in the south-west of the country. A new 220 kV and 110 kV GIS substation are also being constructed on the existing substation site as part of this redevelopment.

SCOPE OF WORK

The scope of work for the project is to replace the existing double-busbar 400 kV (GIS 9 circuits and one combined sectionaliser and coupler) with a new GIS containing 12 circuits and separate sectionalises (3) and end couplers (3). The existing 400 kV GIS was originally installed in the early 1980s and there have been multiple SF6 leaks over the last number of years, making it unsuitable for extending its service life into the future



The new SLD and the old SLD

The new 400 kV GIS is designed to cater for all existing circuits and also cater for any future expansion should it be required. The 400 kV GIS redevelopment is the last stage of a larger project involving the installation of new 110 kV and 220 kV GIS substations on the existing 400 kV site. This work had already taken place and as such also dictated the available footprint area for the new 400 kV GIS substation .

As part of this development two 400 / 220 kV and one 220 /110 kV transformers are also being installed in the substation. The requirement to build three new substation buildings, three new transformer bunds, around the existing substation buildings, 400 kV power cable routes and over head lines greatly restricted both the possible locations of the new 400 kV GIS and the building footprint.

Figure 1: Moneypoint 2012

Figure 2: Moneypoint 2014

SPECIFIC TECHNICAL CHALLENGES

LOCATION OF BUILDING

The limited confines of the site, made it imperative that the selected be as compact as possible to minimise the building footprint. The Asset Owner (ESB Networks) also stipulated that the switchgear must be able to be installed from the both north and south ends of the building to shorten the construction programme, requiring a landing platform at either end, which also contributed to the building length, and required access and egress for loading trucks at both ends of the building. The original plan for the connection to the 400 kV transformers was via busduct, however the Asset Owner subsequently stipulated during the course of the project, that due to previous poor experience with corrosion of busducting on this site, the use of outdoor busducts was to be eliminated as far as possible. This also reduced the footprint available for the building due to the increased footprint required for power cable connections compared to those required for busduct.

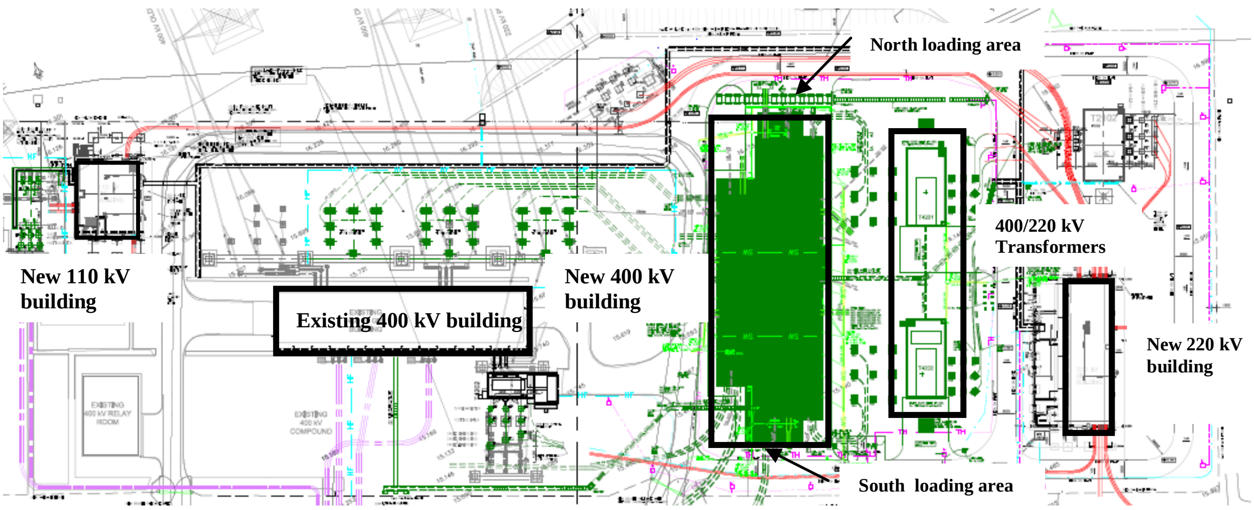


Figure 3: Overview of Moneypoint 400 kV substation and underground services

400 kV NETWORK ISSUES IN IRELAND

Ireland has a weak 400 kV transmission system comprising two 400 kV lines connecting a large generating station on the west coast to the main load center on the east coast

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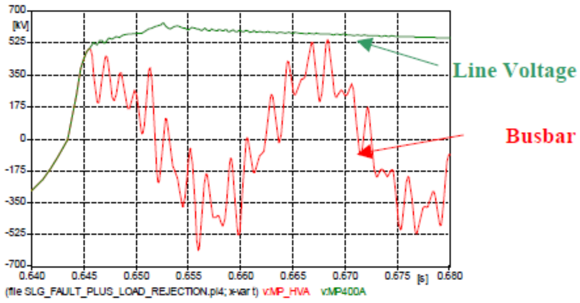
Aside from the BIL requirements, the specification also required that the Transient Recovery Voltage was also specified be in accordance with IEC62271-100 except for a first-pole-to-clear factor which is required to be 1.5 for all test duties. TRV peak value is stated as 624 kV with a pole clearing factor of 1.3, 720 kV for a pole clearing factor of 1.5 in line with IEC 62271-100 values assigned for 420 kV rated equipment.

As per the specification issued by ESB, a first pole to clear factor of 1.5 was required for the TRV of the circuit breaker meeting the insulation requirements. This required the circuit breaker to be rated for a peak TRV of **943 kV**.

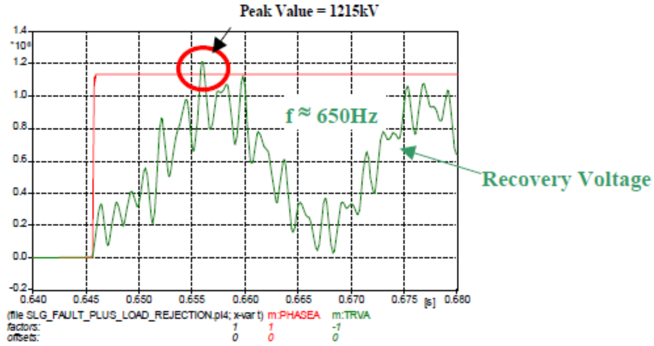
The rated insulation levels of the high voltage equipment shall be as follows as per IEC62271-203:

Lightning impulse withstand voltage (BIL) 1550 kV phase to phase & phase to earth

Switching impulse withstand (SIL) 1175 kV phase to earth & across switching device



Busbar and line Voltages on phase A (fist pole to open) at Moneypoint end



Recovery Voltage across Moneypoint CB pole, Phase A (interrupting line charging current)

Figure 4: Simulation Results

The BIL level was determined by a Power System Study of the entire 400 kV network system, and the results found were equivalent to IEC specified values.

AWARD OF SWITCHGEAR TERM CONTRACT

A number of tenders were received in response to the enquiry. All were carefully scrutinised and the award made was based on technical compliance, size of equipment and ability to deliver in the specified time frame.

BUILDING DESIGN

Although the switchgear term contract was only awarded in December 2013, the overall programme required that site construction work begin in March 2014. This meant that building design had to be well underway before the switchgear was selected. Therefore the original design for the new Moneypoint 400 kV GIS Substation building was based on the original planning permission drawings which allowed for a worst case (i.e. 550 kV) switchgear installation. As the switchgear finally selected was a considerably smaller 400 kV design it was decided at this point to redesign the building down to the dimensions required by the chosen switchgear to reduce cost and programme duration.

The Moneypoint project team, encompassing engineers from the HV Projects, Civil and Environmental, HV Cables and HV Primary Plant departments in ESB International redesigned and resubmitted the planning permission for the new building based on the new term contract GIS specifications in a 3-month time frame ensuring the original civil construction start date of the 1st of March 2014 was met. The new design reduced the footprint of the building by 35% and also reduced the construction programme by 3 months.

This was achieved through a collaborative effort with all design disciplines mentioned previously, the decision to have all design disciplines visit the switchgear manufacturer's factory to help understand the design and the use of 3D Modelling to improve the design and decision process.

Revit a BIM (Building Information Modelling) software package was used to design the GIS building and the switchgear supplier's 3D model was inserted into this package. As the compact switchgear is largely assembled off-site, the 3D model of the building and the switchgear allowed us to position the switchgear within the building, ensure the correct alignment of cable openings, avoid HV cable clashes, ensure access for maintenance and ensure that measuring devices like pressure gauges and position indication displays were easily accessible once the switchgear was assembled on site.

This model was used at weekly project design meetings to review the civil building design in 3D to enable all design disciplines to feed in to the building design process and review collectively design issues that could not be foreseen on a simple 2D model.

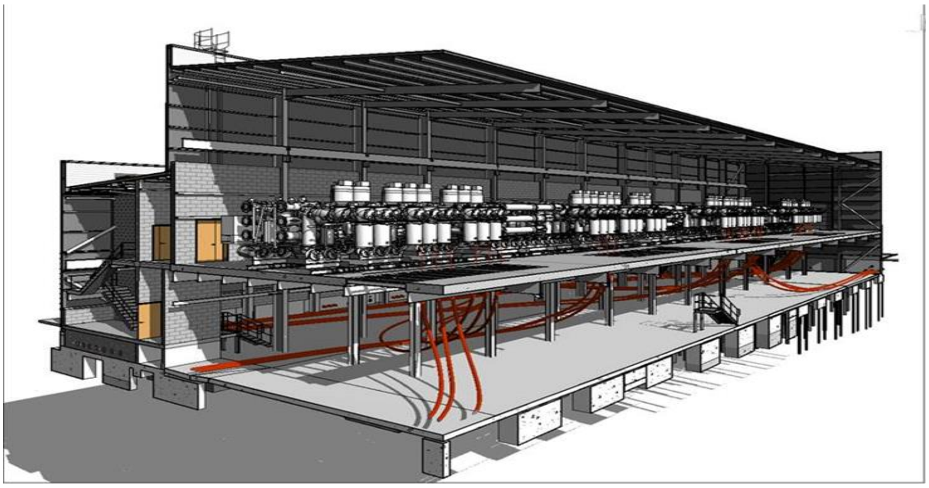


Figure 5: 3D Model View of 400 kV Building and Switchgear

INSTALLATION OF SWITCHGEAR

The switchgear was delivered to site over a ten week period, with two bays delivered per shipment. As the switchgear is preassembled off site, a full bay, excluding voltage transformers and cable boxes was transported in one unit. Each bay was offloaded from the truck on to a designated landing area, transport packaging removed and craned on to the temporary rails on the landing platform. From here each bay was pushed in by hand to its designated position using the manufacturer's track and rail system. The bays, once in position, were then coupled together. As the bays were preassembled, significant time savings weere gained, with the installation being considerably faster than more traditional 400 kV switchgear which is not delivered preassembled to site. It took on average two/three days to install each bay and a further one/two days to couple adjoining bays together.

Figure 6: Delivery of switchgear

Figure 7: Switchgear being moved into position

Other benefits of the switchgear being preassembled off site included a reduction in safety risks on site with a reduction in the assembly of heavy components and working at height required and a reduction in the manpower required on site. Also as each bay was off- loaded from the delivery truck to inside the switchroom on the day of delivery, there was no requirement for a large storage area for the GIS material. The GIS accessories, including tools, cable boxes and voltage transformers were stored underneath the landing platform and in the switchroom itself. This is in comparison to a previous 220 kV 20 bay installation where 650 boxes had to be stored externally, requiring additional site security and careful coordination to ensure all equipment was available when required.

Figure 8: Overview of switchgear in position

A key component of the success of the installation was the management of the delivery of the switchgear. As the only mechanism of fixing a bay into is position was using the track and rail system each bay had to arrive in sequence. There was tight deadlines on the construction phase of the project and there were significant civils works ongoing during the delivery period particularly at the south end of the site with new 400 kV cable ducts being installed. These issues were flagged in advance and determined the sequencing of the switchgear with only the north loading platform available during delivery.

CONCLUSION

The 400 kV switchgear has been installed and passed the HV test in 2015. The 400 kV substation is currently being commissioned with a planned energisation date in Q3 2016. The switchgear chosen met the technical requirements for the Irish 400 kV transmission system and due to its compact nature resulted in programme and financial savings for the project.

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