MOTT MACDONALD

Technical Note

Project:	CMS HVDC VSC Link		
Our reference:	333022/TN/KERGORD/UPGRADE	**Your reference:**	TBA
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Subject:	Review of Kergord Converter Station Upgrade from 600MW to 800MW		

Executive Summary

This note details the impact of upgrading the Kergord converter station from 600MW to 800MW. The technical review included in this note has been carried out from the perspective of changes in the design of the equipment, CAPEX and OPEX. The review covers the uprating of the converter within the current three-terminal design.

Related Documents

- Main Circuit Parameters, [redacted]
- Chopper Study, [redacted]
- Insulation Coordination, [redacted]
- Transient Overvoltage Study, [redacted]
- Transient Currents, [redacted]
- AC Filter Performance, [redacted]
- Dynamic Performance Study, [redacted]
- DC Harmonic Study, [redacted]
- Converter Valve Datasheet, [redacted]
- HVDC Protection Settings & Coordination, [redacted]

Current Status of the Design

It is understood that the converter and its equipments for Kergord converter station is designed or rated for maximum active power of 600MW and reactive power of ±197MVAr. It is assumed that all design or rating studies, equipment specifications and outline station layouts are complete but no equipments have been manufactured or tested other than control cubicles that were built to factory test the functions related with multi-terminal operation. It is also assumed that no civil works at Kergord has started.

Findings

Our review concludes that the following studies and equipments will see an impact due to increase in rating of the Kergord converter station to 800MW:

Item Number	Description	Impact on the Design of Kergord Converter Station	Additional Comments related with the Design of Blackhillock and Spittal Converter Stations, if applicable
1	Interface Transformer and Coolers	The MVA rating will increase which will result in the change of the overall dimensions, tap-changer and transportation weight. It is also anticipated the change in the overall dimensions may influence the layout of the coolers, the associated fire walls and the assumed overall station layout.	It is understood that the DC voltage is controlled at DCSS implying that any increase in the voltage drop in the cable connected between Kergord and DCSS will only be fed into converter station control at Kergord (not Blackhillock or Spittal) to balance out the DC power during multi-terminal operation. Based on this assumption, it is concluded that the design of the tap-changer for the interface transformers as well as operating limits of modulation index at Blackhillock and Spittal will see no impact.
2	Converter Valve and Valve Cooling	The converter valve currently specified for the Kergord is same as for the Spittal, so a change in the rating will not result in a change in the valve cell type or number of valve cells. However, there will be an increase in size or dimensions of the associated cooling equipment which is expected to be accommodated within the assumed overall station layout. The related report or data sheet will also require updating.	

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3	DC Smoothing Reactor	The current rating of the DC smoothing reactor will increase and may result in the redesign of DC reactor to meet the required insulation class. The increased value of the rated current will also increase the electrical field clearance envelope around the reactor but it is expected that such increase will not have any impact on the dimensions of the DC hall.	
4	AC Phase Reactor	The current rating of the AC phase reactor will increase and may result in the redesign of AC phase reactor to meet the required insulation class. The increased value of the rated current will also increase the electrical field clearance envelope around the reactor but it is expected that such increase will not have any impact on the dimensions of the reactor hall.	
5	Through-Wall Bushing	There will be an increase in the rated current for all through-wall bushings but it is not expected that the dimensions of the bushings will see any significant change hence, neither the assumed overall station layout.	
6	Surge Arrester	There will be an increase in the energy absorption rating of all surge arresters due to increase in the TOV as well as power rating. It is probable that some additional columns will be required that may or may not result in single-housing arresters to become multi-housing arresters. It is further expected that such change in the design will be accommodated within the assumed overall station layout.	The design of the DC side surge arresters will be impacted but it is assumed, subject to confirmation by study, that suitable design margins already assumed in the design of such arresters should be able to accommodate the increase in the energy.

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7	DC Chopper	There are no significant changes anticipated to the chopper valve as the number of cells is the same as that for Spittal. However, it is very likely that the design of chopper resistor will change and this change will be accommodated within the assumed overall station layout.	
8	BR2 Capacitor	The current design appears to have used the Spittal design for BR2 capacitor. However, increase in the rating of the Kergord station will have impact on the rating of BR2 capacitor but it is expected that such increase will not have any impact on the dimensions of the unit.	
9	Voltage Measuring Instrument Transformer	The change in the power rating will not have any effect on the rating of the voltage measuring instrument transformers.	
10	Current Measuring Instrument Transformer	The change in the power rating will have an impact on the rating as well as ratio of the current measuring instrument transformers. However, it is expected that all changes in the design will be accommodated in the assumed overall station layout.	The design value of the fault current will see increase, to be determined by re-study, but it is expected that suitable design margins already assumed in the design should be able to accommodate this change.
11	Grounding Switch	It is assumed that grounding switches are not used for discharging of stored energy but only be used during maintenance. Therefore, change in the power rating will have no impact on the design of the grounding switches.	

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12	Disconnector	The change in the power rating will have an impact on the design of the disconnectors but all such changes will be accommodated in the assumed overall station layout.	
13	DC Cable	It is believed that the current design of the DC cable is over-sized for the rated continuous current and that the short-time withstand current and loss capitalisation are factors in the dimensioning. It is still anticipated that the minor constructional design changes or tweaks will be required and those changes will be accommodated within the assumed electrical as well as mechanical design of the cable. This assumption is subject to confirmation from the supplier.	If it is seen, after re-study for item 1, that the assumptions can be complied with changing the electrical parameters of the Kergord DC cable then such change shall be done to reduce overall impact on the bespoke equipments already supplied.
14	Main Circuit Parameters	This study shall be re-performed based on the assumptions stated above for items 1, 3, 4, 5, 9, 10 and 12.	The objective of the re-study shall also be to minimise the impact on the bespoke equipments already supplied.
15	Transient Overvoltage Study	This study shall be re-performed based on the assumptions stated above for item 6.	The objective of the re-study shall be to verify that any increase in the energy rating for the surge arresters at Blackhillock and Spittal is within the actual design value of energy absorption capability determined for the multi-terminal configuration.
16	AC Filter Performance Study	This study shall be re-performed. It is anticipated that filter configuration or type or tuned frequencies will not change but the rating of the filter equipments will increase.	

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		Furthermore, any changes to the layout will be accommodated within the assumed overall filter area.	
17	DC Filter Performance Study	This study shall be required to be re-performed after subject to confirmation of the assumptions made for item 13 from the supplier for the purpose of updating the results.	
18	Insulation Coordination	This study may not be required to be re-performed subject to confirmation of the assumptions to be true for item 15 from the supplier.	
19	Transient Currents	This study shall be re-performed and all transient currents shall be updated. It is anticipated that all increase in the transient currents will be accommodated by the suitable design margins or values for the equipments.	It is anticipated that increase in all transient currents will be accommodated by the suitable design margins or values for the equipments. However, if not then some reduction may be required in the allowable future A and B contribution to mitigate the impact.
20	Dynamic Performance Study	This study shall be re-performed to include scenarios according to the new level of rated DC power for all assumed network configurations.	This study shall be re-performed to include additional cases that would call for switch of the controller for additional scenarios at low power levels (lower than 300MW) for assumed network configuration 3.
21	DC Protection Settings	The parts of this report shall be updated following re-studies for all bespoke main equipments (items 2, 7, 14, 15, 16, 17, 19 and 26) and DC cable (item 13).	
22	132kV Switchgear	Increase in the power rating will result in the AC side current	

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		increasing to about 4500A and an AC CB rating of circa 4100A. ENA approved switchgear larger than 3105A is not available. Therefore, an oversized switchgear (most probably, 400kV/5000A) will have to be used that will result in the increase of the size of the GIS building. Alternatively, a bar voltage at Kergord can be increased from 132kV to 275kV which would permit the use of the same type of switchgear as used at Spittal but this will have far greater impact on the HV equipment design connected to the AC side and on the interface with VIKING and SHEPD. Therefore, such alternative is not studied further.	
23	AC Cable	There will be multiple (minimum of three, possibly four) cables required to work in parallel configuration to comply with the new rated current on the AC side, which may not be accommodated within the assumed overall station layout. Alternatively, a GIB (gas insulated busbar) solution may be considered which will also require the transformer along with other HV equipment connections to the AC side and the assumed overall station layout to be re-engineered.	
24	Control Cubicle	There may be replacement or retuning of certain components required but no replacement or retuning is likely to be expected to change the design of control cubicles.	There may be replacement or retuning of few components required but no replacement or retuning is likely to be expected to change the design of control cubicles.

Item Number	Description	Impact on the Design of Kergord Converter Station	Additional Comments related with the Design of Blackhillock and Spittal Converter Stations, if applicable
25	Factory Acceptance Test	FAT for all primary equipment will require no additional effort as no FAT for any primary equipment has been performed. Re-FAT for control cubicles will be required in accordance with the item 20 and 21.	FAT for modified surge arresters or newly sourced surge arresters will be required. Furthermore, recalibration of few measuring instrument transformers may be required. Re-FAT for control cubicles will be required in accordance with the item 20 and 21.
26	Insertion Resistor	The change in the rating may be required following receipt of the information from the supplier for item 13. However, it is anticipated that any change in the dimensions or rating will be accommodated within the assumed overall station layout.	

Project Programme or Plan

It is clear from the findings that to accommodate upgrade of the Kergord from 600MW to 800MW, a re-design of most of the HV equipments and some part of the assumed overall station layout is required. On the basis of the assumptions made in this document and considering suitable procurement process shall be sought for this upgrade, a delay in the current project schedule is estimated as follows:

Activity or Period in the Project Schedule	Estimated Delay, in months	Additional Comments, if any
Pre-Contract		
Procurement Process	9-12	Engage suppliers, agree the pre-conditions related with the upgrade as the change in the rating will have an impact on the AC substation design, DC converter design and overall site

		layout, updating of works information, retendering and review of tenders prior to contract award
Project Delivery (Post-Contract)		
Engineering Design & Studies	6-8	Perform rating studies, updating of equipment specifications and reports that have already been completed for the 600MW design and discuss FAT
Manufacturing & Factory Testing	3-4	Due to expanded scope of FAT
Shipping, Civils, Installation & Commissioning	0	
System & Site Testing	0	
Total	18-24	

CAPEX and OPEX

It is clear from the findings that to accommodate upgrade of the Kergord from 600MW to 800MW, a re-design of most of the HV equipments and some part of the assumed overall station layout is required. On the basis of the assumptions made in this document, an increase in the CAPEX and OPEX is estimated as follows:

Expense	Increase in CAPEX or OPEX, in MGBP	Additional Comments, if any
Procurement Process	[redacted]	It is an expense to be incurred by SHET
Cost associated with Manhours for Engineering Design or Studies & Factory Testing	[redacted]	To be spent by suppliers

Cost for Equipments	[redacted]	Includes primary equipment, DC cable, AC cable, AC switchgear for all stations excluding alternatives discussed in this document
Shipping, Insurance, Civils, Installation, Commissioning & Site Testing	[redacted]	Due to increased capital value and change in the dimensions of primary equipments
Cost associated with Change in DC Cable Design	[redacted]	It is a technical risk that would become reality should the relevant assumptions included in this document cannot be adhered to by the supplier
Cost associated with Design Assurance or Review	[redacted]	To be spent by the consultant
Total	[redacted]	Worst-case

Conclusion

This note details the impact on the technical and commercial design associated with the upgrade of Kergord converter station from 600MW to 800MW.

It is concluded that contract award will be delayed by circa 9-12 months. However some of this possible delay could be absorbed by an early commencement of the re-design.

It is concluded that contract delivery will be delayed by circa 8 months as we believe that factory testing will not be on critical path and run concurrently with part duration of engineering design.

[redacted]

[redacted]