Angle-DC

Benefits Report

About Report		
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Contents

Executive Summary

Angle-DC is a smart and flexible solution for reinforcing distribution networks. The project has created a controllable bidirectional Direct Current (DC) link between two sections of our network, Isle of Anglesey and North Wales. Angle-DC is converting existing 33kV Alternating Current (AC) assets to DC.

The benefits of the MVDC link were quantified using loss reduction and generation headroom increase metrics.

Based on the forecast load growth published in SPEN's DFES, the introduction of the MVDC link from Mainland Wales to Anglesey can be shown to have significant net positive benefits in terms of loss reductions and unlocking headroom for the increased accommodation of generation from renewable sources.

For a two-fold increase in network loading by 2030 and four-fold increase in network loading by 2040 (driven by the anticipated uptake in electric vehicles and heat pumps across Nortech Wales), relative network losses within the 33kV network can be reduced by up to 8.8 GWh/year and 35.2 GWh/year respectively through the optimised operation of the MVDC link delivered by a control system utilising network-wide measurements.

The Seasonal Setpoint solution can unlock an additional 24 MW of generation headroom compared to the base case scenario, equating to an additional energy yield of 203.0 GWh/year.

The MVDC Control System (utilising network-wide measurements) can unlock an additional 40 MW of generation headroom compared to the base case scenario, equating to an additional energy yield of 350.4 GWh/year.

1 Introduction

Angle-DC is a smart and flexible solution for reinforcing distribution networks. The project has created a controllable bidirectional Direct Current (DC) link between two sections of our network, Isle of Anglesey and North Wales. Angle-DC is converting existing 33kV Alternating Current (AC) assets to DC.

1.1 Objectives

The objectives of Angle DC are as follows:

1. Trial the first flexible MVDC link in the Great Britain (GB) distribution system.
2. Trial conversion of an AC circuit to DC operation to enhance circuit capacity.
3. Trial real-time holistic circuit condition monitoring of a DC circuit converted from AC to provide the evidence and confidence for DNOs.
4. Provide real-life data on MVDC converter operation under various loading conditions.
5. Provide real-life data on cable ageing mechanism.
6. Develop technical guidance, recommendations and policy documents for planning, procurement, operation and control strategy of MVDC converters and MVDC links.
7. Create a supply chain and stimulate a competitive MVDC market.
8. To bridge the gap between transmission network and low voltage distribution DC technologies.
9. Explore the feasibility of Angle-DC.

1.2 Overarching Benefits

Through its lifetime of operation, Angle DC will deliver the following benefits for SPEN's customers [1]:

1. Increasing the capacity for load and generation connections. Reduced sleeving of Horizon Nuclear Power transfer via the parallel 33kV network.
2. Enhanced power flow through an existing circuit to defer reinforcement which may be necessary for some connection requests.
3. More precise control of the flow of power in the distribution circuit for improved efficiency to avoid naturally occurring AC overloads. This prevents the possibility of overload of the circuit, helping to reduce the number of faults.
4. Control of voltage at either end of the distribution circuit to enhance the flow of electricity to customers.
5. Control of reactive power flow at both ends of the distribution circuit.
6. To lower losses and save wasted energy in the wider distribution network due to the improved voltage control.
7. Rapid support to the system voltage during faults to enhance the electricity quality of supply to our customers.
8. Fault level decoupling between distribution systems.
9. Enables faster access to the network for renewable connections. This helps customers who wish to connect low carbon technologies such as wind.

This report quantifies the impact the MVDC link will have on network losses and generation headroom during the MVDC link lifetime of operation using the most conservative of SPEN's Distribution Future Energy Scenarios (DFES) [2] pathways to Net-Zero.

2 Benefits Quantification Methodology

The benefits of the MVDC link were quantified in the following way:

1. The datum losses and generation headroom were quantified for the base case scenario (10MW import to Anglesey) using IPSA for 2019 loading data based on half hourly metered load and existing generation data across the whole of SPEN's North Wales network within the sphere of influence (SoI) of the MVDC link.
2. Loading was scaled accordingly to SPEN's DFES forecasts for the 2025 to 2040 horizon, using a five-year resolution and selecting a conservative load growth pathway to represent the minimum forecast benefits delivered by the MVDC link.
3. For each five-year forecast horizon, the datum losses and generation headroom were re-calculated using IPSA and scaled metering values. In addition, the losses and generation headroom were calculated for two MVDC link scenarios: (i) Operating the MVDC link with seasonal setpoints; (ii) operating the MVDC link with an optimised set point profile based on a control system utilising network-wide measurements.

3 Benefits Quantification Results

3.1 Losses Quantification

The results of the loss quantification are shown in Figure 1 based on the base-case datum and marginal losses for the two control solutions as given in Table 1.

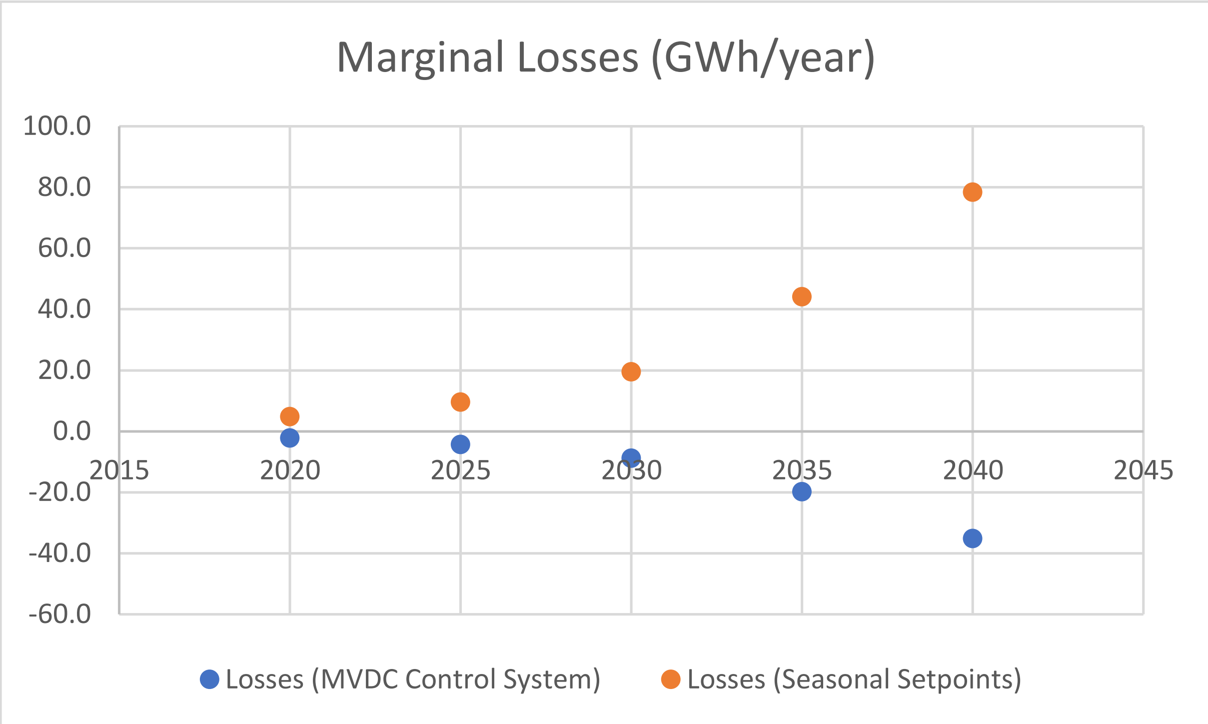

Figure 1: Quantification of MVDC Link Loss Reduction Benefits

Table 1: Loss Reduction Datum

Year	Base-Case Losses (GWh/year)	Marginal Losses based on Seasonal Setpoints (GWh/year)	Marginal Losses based on MVDC Control System (GWh/year)
2020	174.2	+4.9	-2.2
2025	341.4	+9.6	-4.3
2030	696.8	+19.6	-8.8
2035	1,567.8	+44.1	-19.8
2040	2,787.2	+78.4	-35.2

For a two-fold increase in network loading by 2030 and four-fold increase in network loading by 2040 (driven by the anticipated uptake in electric vehicles and heat pumps across Nortech Wales), relative network losses within the 33kV network can be reduced by up to 8.8 GWh/year and 35.2 GWh/year respectively through the optimised operation of the MVDC link delivered by a control system utilising network-wide measurements.

3.2 Generation Headroom Quantification

The results of the generation headroom quantification are shown in Table 2 based on the base-case datum and marginal headroom for the two control solutions both in terms of MW headroom and GWh/year energy yield.

Table 1: Generation Increase Datum for MVDC link operation

Scenario	Generation Headroom (MW)	Energy Yield (GWh/year)
Base Case	145.7	995.9
Seasonal Setpoints	169.6	1,198.9
MVDC Control System	185.7	1,346.5

The Seasonal Setpoint solution can unlock an additional 24 MW of generation headroom compared to the base case scenario, equating to an additional energy yield of 203.0 GWh/year.

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4 Conclusions and Recommendations

This report has quantified the impact the MVDC link will have on network losses and generation headroom during the MVDC link lifetime of operation using the most conservative of SPEN's Distribution Future Energy Scenarios (DFES) pathways to Net-Zero.

Based on the forecast load growth published in SPEN's DFES, the introduction of the MVDC link from Mainland Wales to Anglesey can be shown to have significant net positive benefits in terms of loss reductions and unlocking headroom for the increased accommodation of generation from renewable sources.

For a two-fold increase in network loading by 2030 and four-fold increase in network loading by 2040 (driven by the anticipated uptake in electric vehicles and heat pumps across Nortech Wales), relative network losses within the 33kV network can be reduced by up to 8.8 GWh/year and 35.2 GWh/year respectively through the optimised operation of the MVDC link delivered by a control system utilising network-wide measurements.

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References

[1] SP Energy Networks "Distribution Future Energy Scenarios". Available at: https://www.spenergynetworks.co.uk/pages/distribution_future_energy_scenarios.aspx

[2] CIGRE WG C6/B4.37 Technical Brochure 875 "Medium Voltage DC Distribution Systems". Available at: https://e-cigre.org/publication/875-medium-voltage-dc-distribution-systems

Glossary of Terms

Abbreviation	Definition
CIGRE	International Council of Power Systems Experts
DC	Direct Current
DFES	Distribution Future Energy Scenario
GW	Giga Watt
GWh	Giga Watt hour
MV	Medium Voltage
SoI	Sphere of Influence
SPEN	SP Energy Networks

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