ANBARIC
Scaling Renewable Energy

New Jersey Board of Public Utilities

State Agreement Approach Project Overviews

March 22, 2022

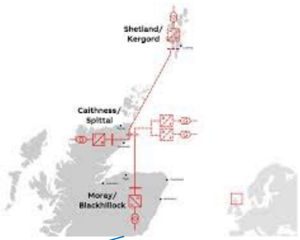
Appendix

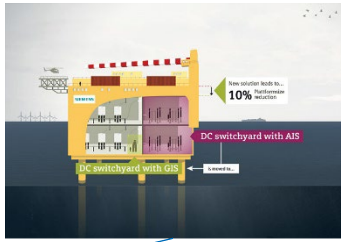
MMC-VSC HVDC

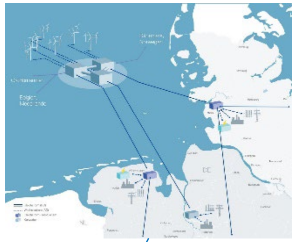
- Modular multi-level voltage sourced converter
- State-of-the-art, qualified and with over 10 years of operational experience
- Low footprint
- Fully controllable
- Efficient
- High power quality
- Valve design
  - Nr of modules
    - Voltage
    - Redundancy
    - Tower arrangement
  - IGBT current rating
    - Converter power rating

Same physical valve design is used for a range of power ratings

Operational experience by time of COD







2019 2020 2021 2023 2025 2027 2029 2030 2031 2032 2033

2019: 400 kV HVDC XLPE cables 1 GW NEMO link Belgium

2020: Meshed onshore HVDC grid 500 kV 3 GW Zhangbei, China

2021: HVDC offshore 400 kV 1.1 GW Rudong project, China

2023: Multi-terminal HVDC 1200 MW 320 kV CMS system, Scotland, UK

1st 1100 MW

2025: 320 kV HVDC GIS 900 MW Borwin 5 & Dolwin 6 projects Germany

2027: HVDC Multi-terminal readiness & HVDC GIS 2 GW 525 kV IJmuiden Ver Netherlands

2nd 1148 MW 1510 MW

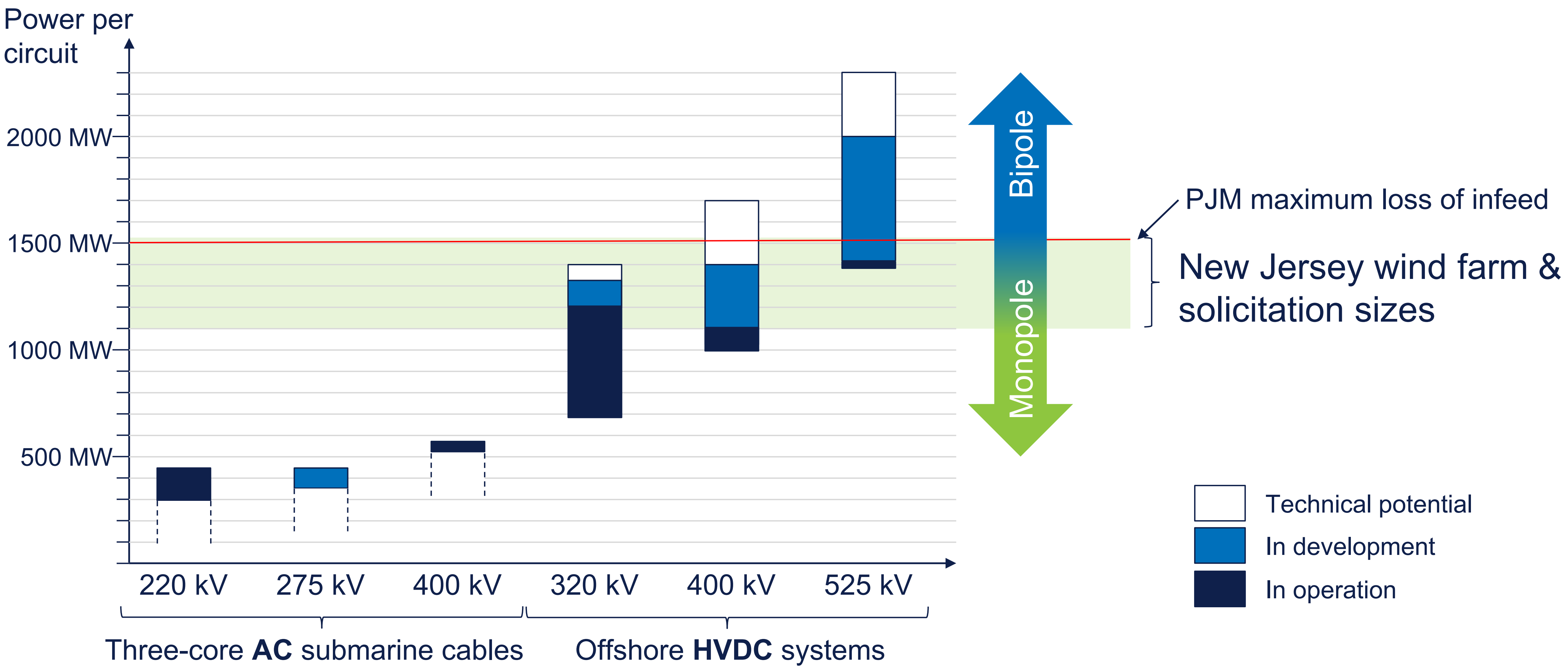
3rd 1200 MW

4rd 1200 MW

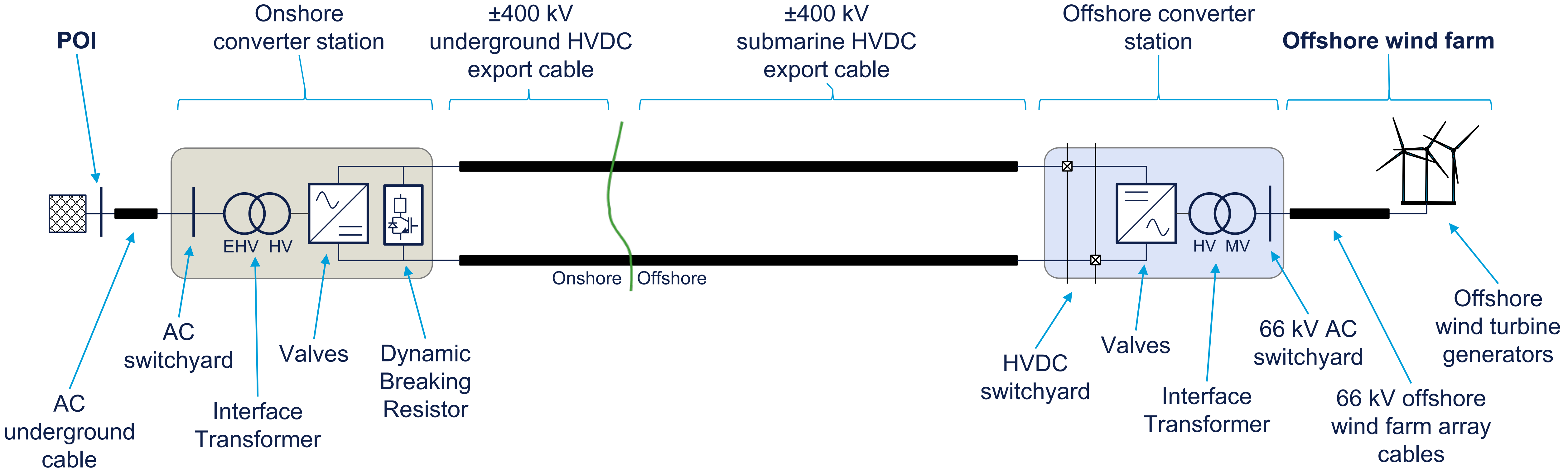
2032: Meshed offshore HVDC grid 525 kV Windstrom-Booster Germany

5th 1342 MW

Export link: Technology, voltage level & configuration



Modular building block – Option 2

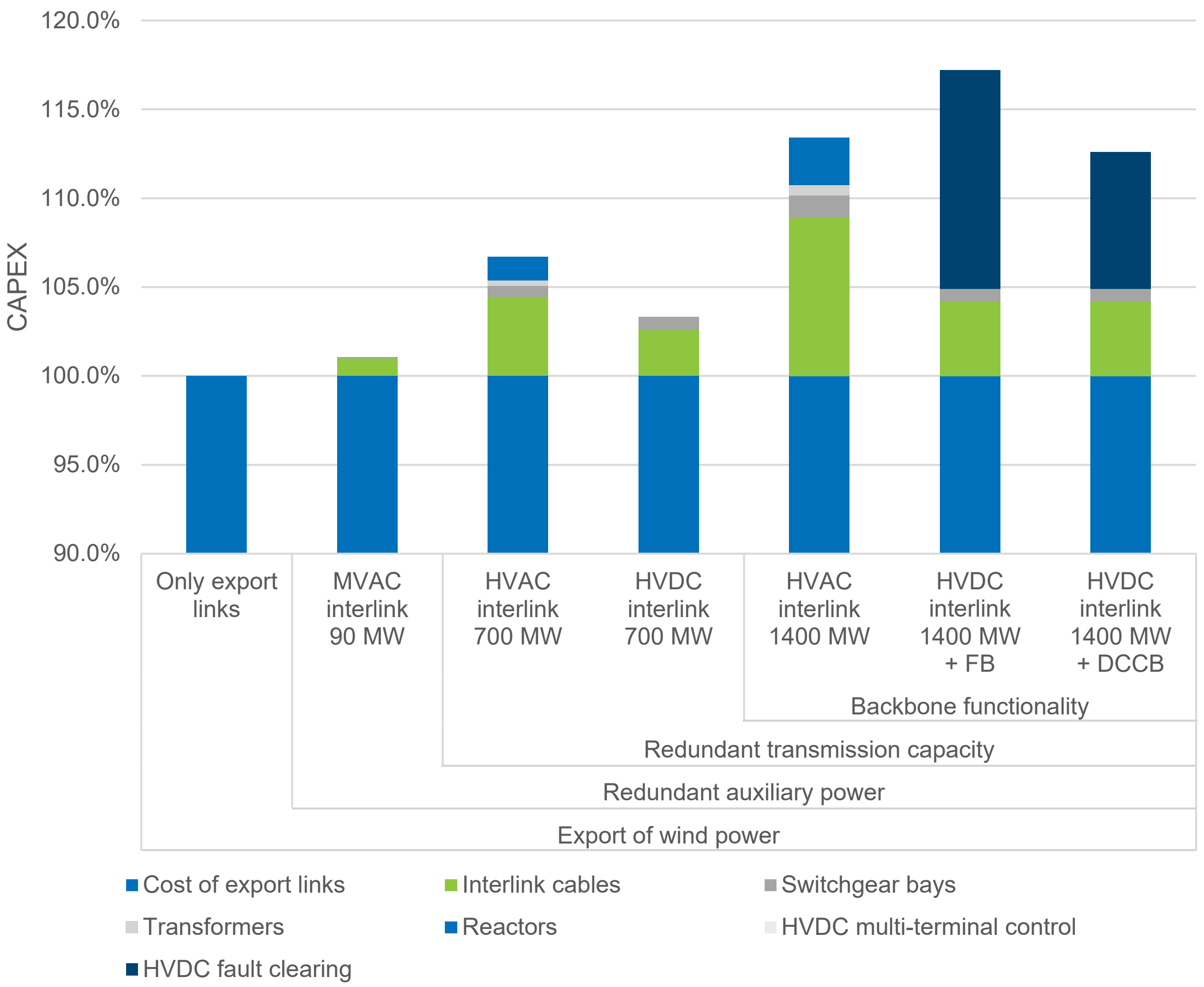


Offshore platform interlinks

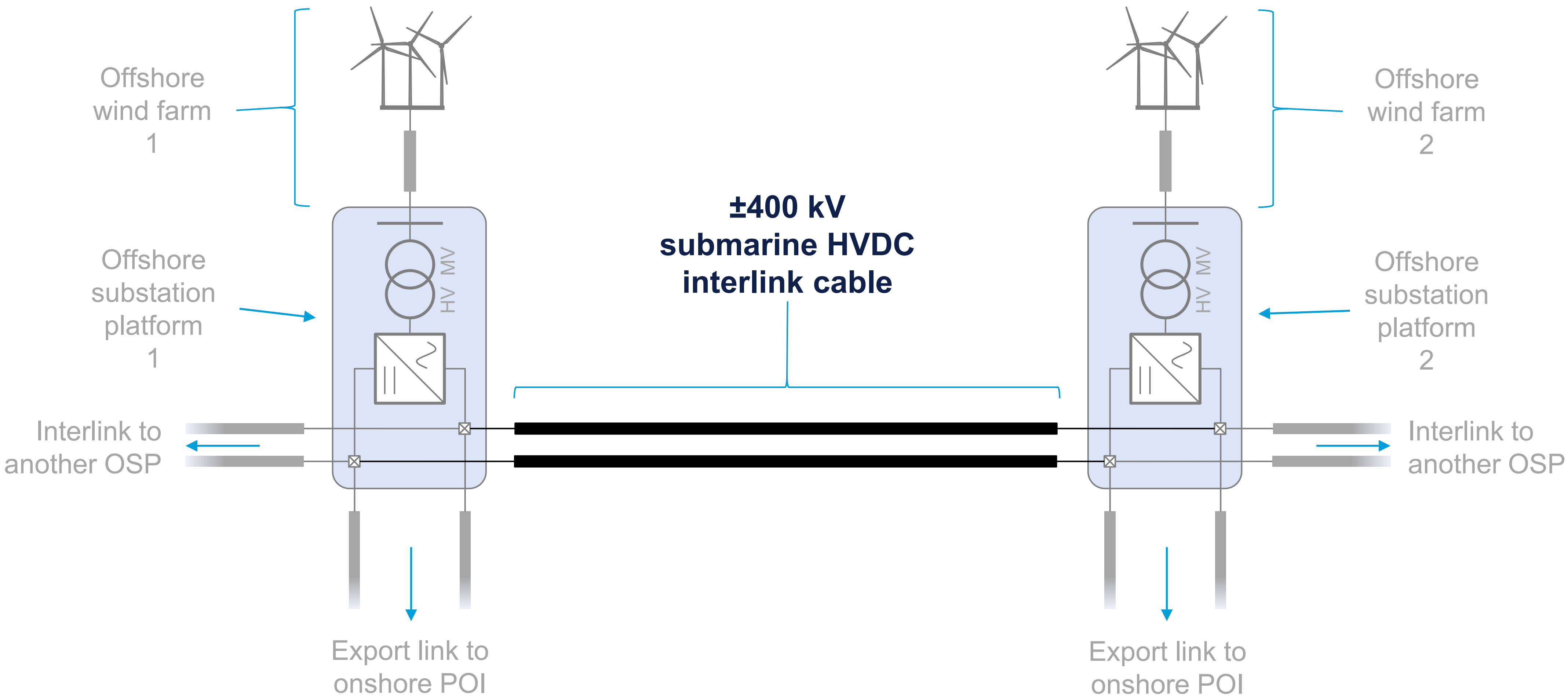
- **Functionality**
  - Supply redundant auxiliary power
  - Redundant transmission capacity
  - Backbone functionality

Technology
  - MV AC
  - HV AC
  - HVDC

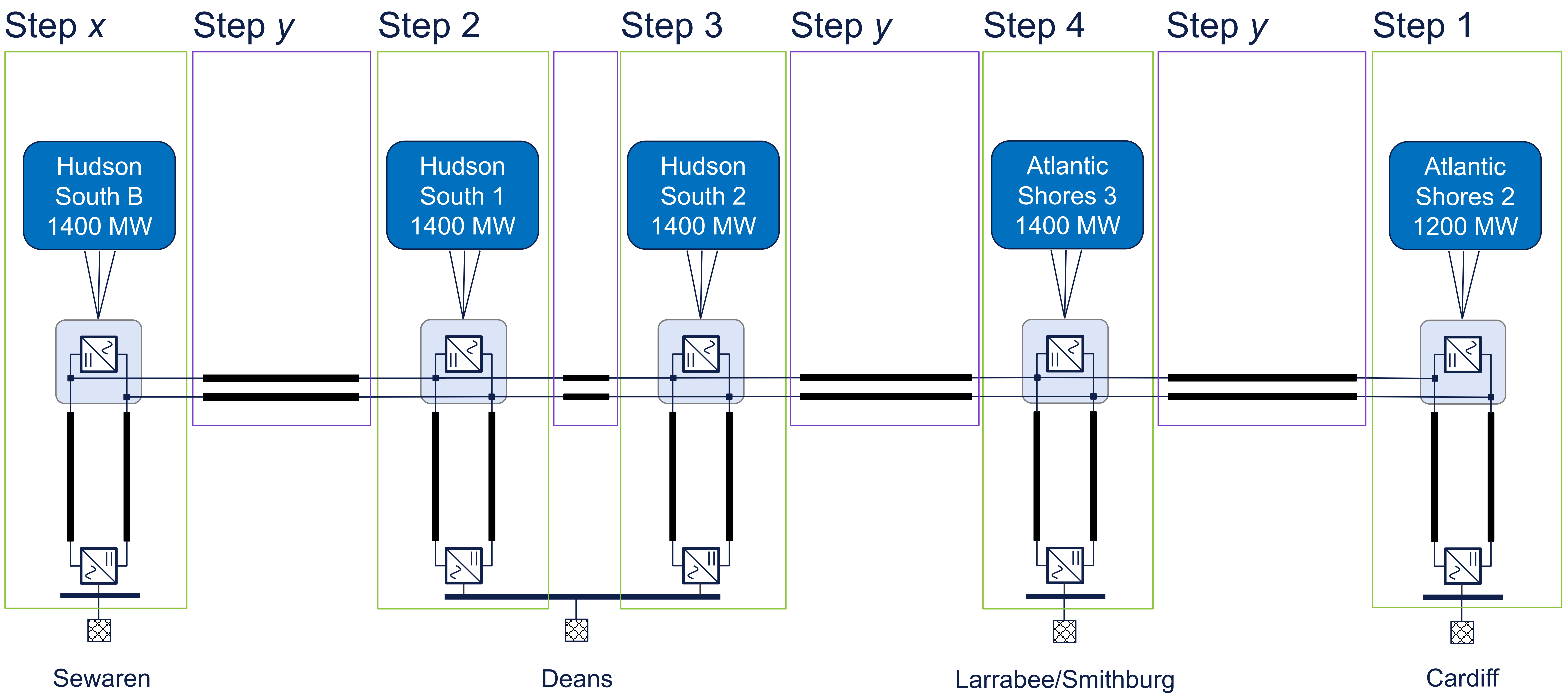
- **Capacity**
- **HVDC Fault clearing**
  - Full-bridge converters
  - HVDC circuit breakers



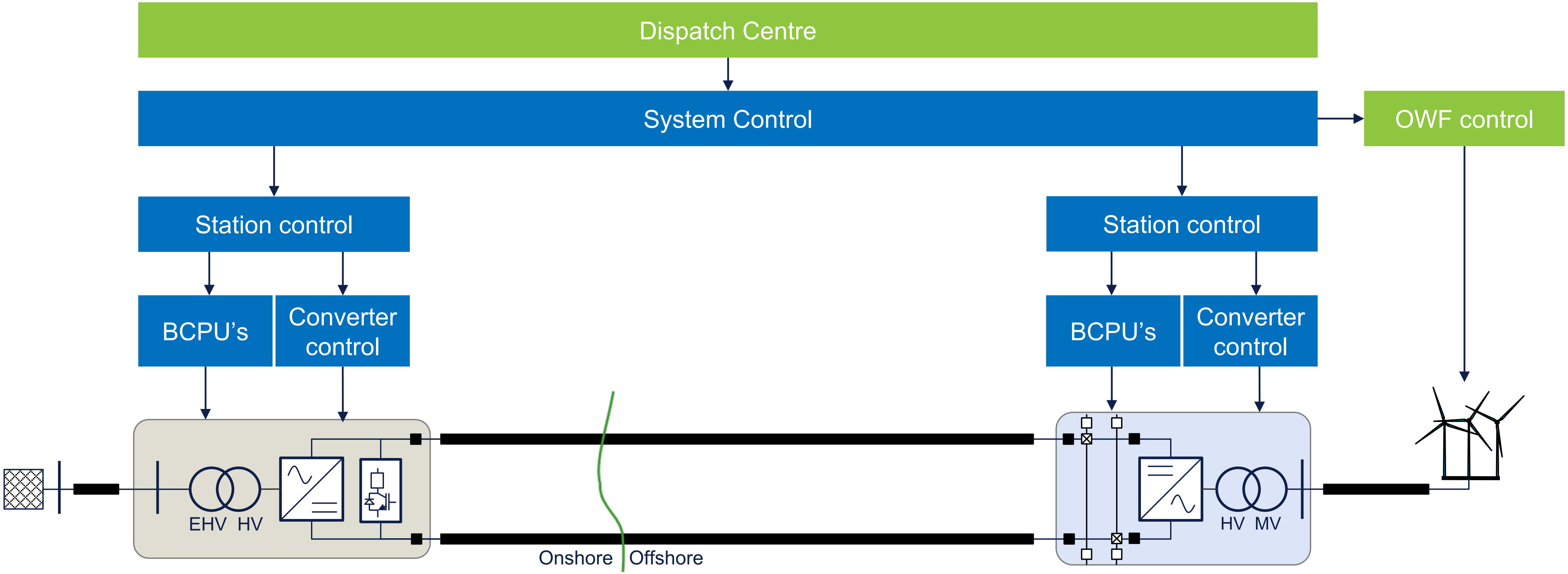
Modular building block – Option 3



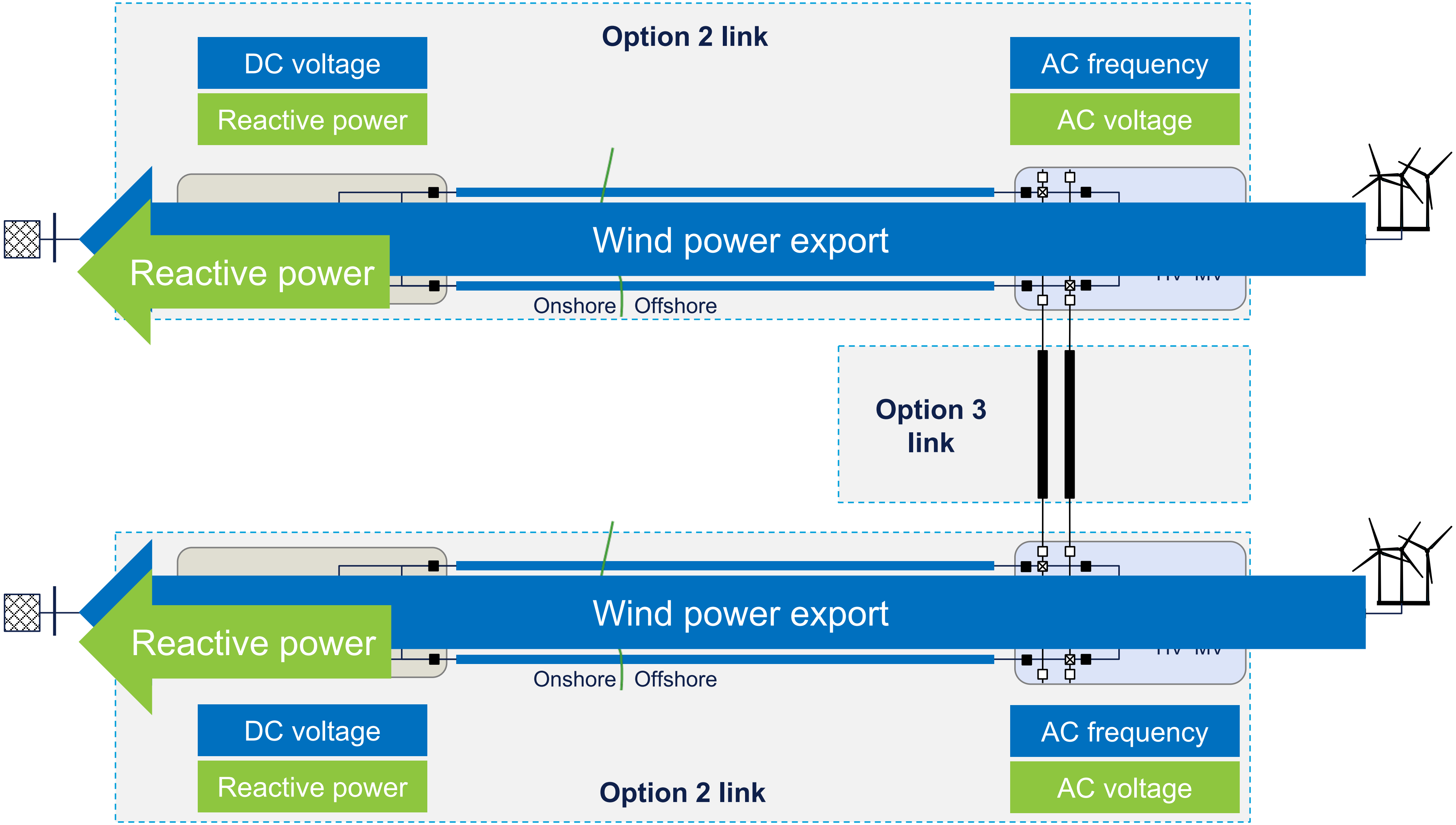
Example modular grid development



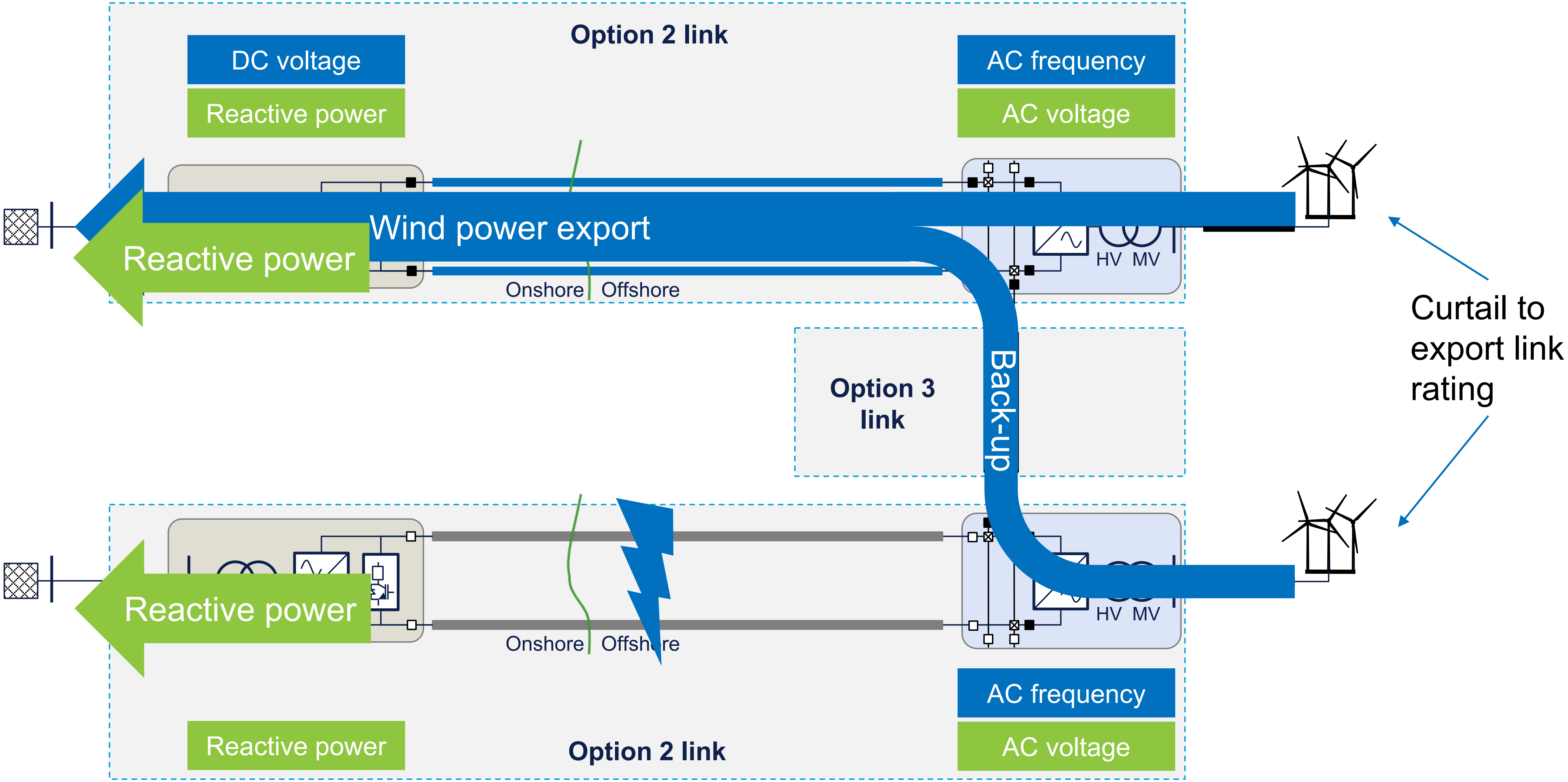
Control of modular export links



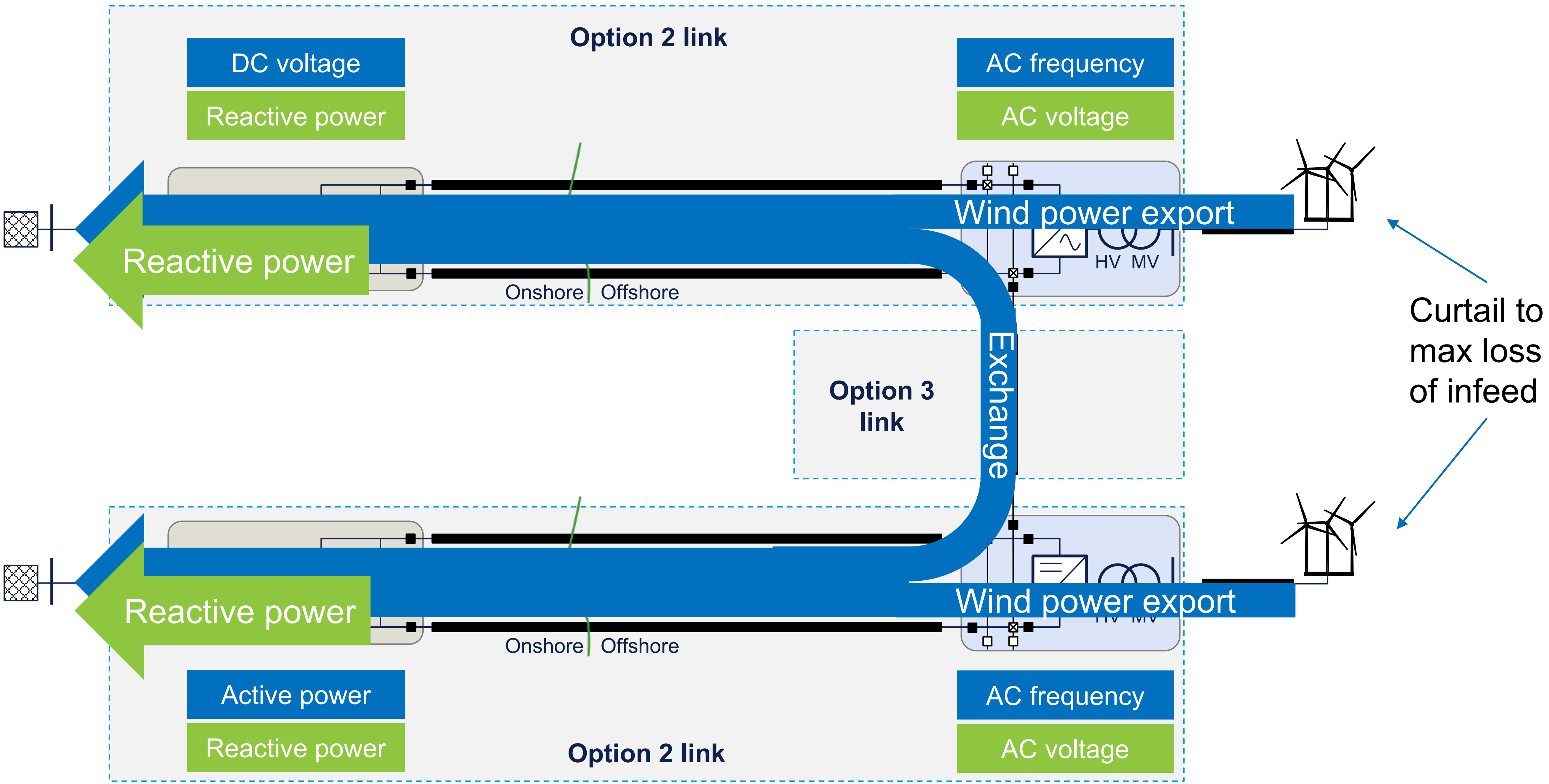
Control modes – Offshore wind export



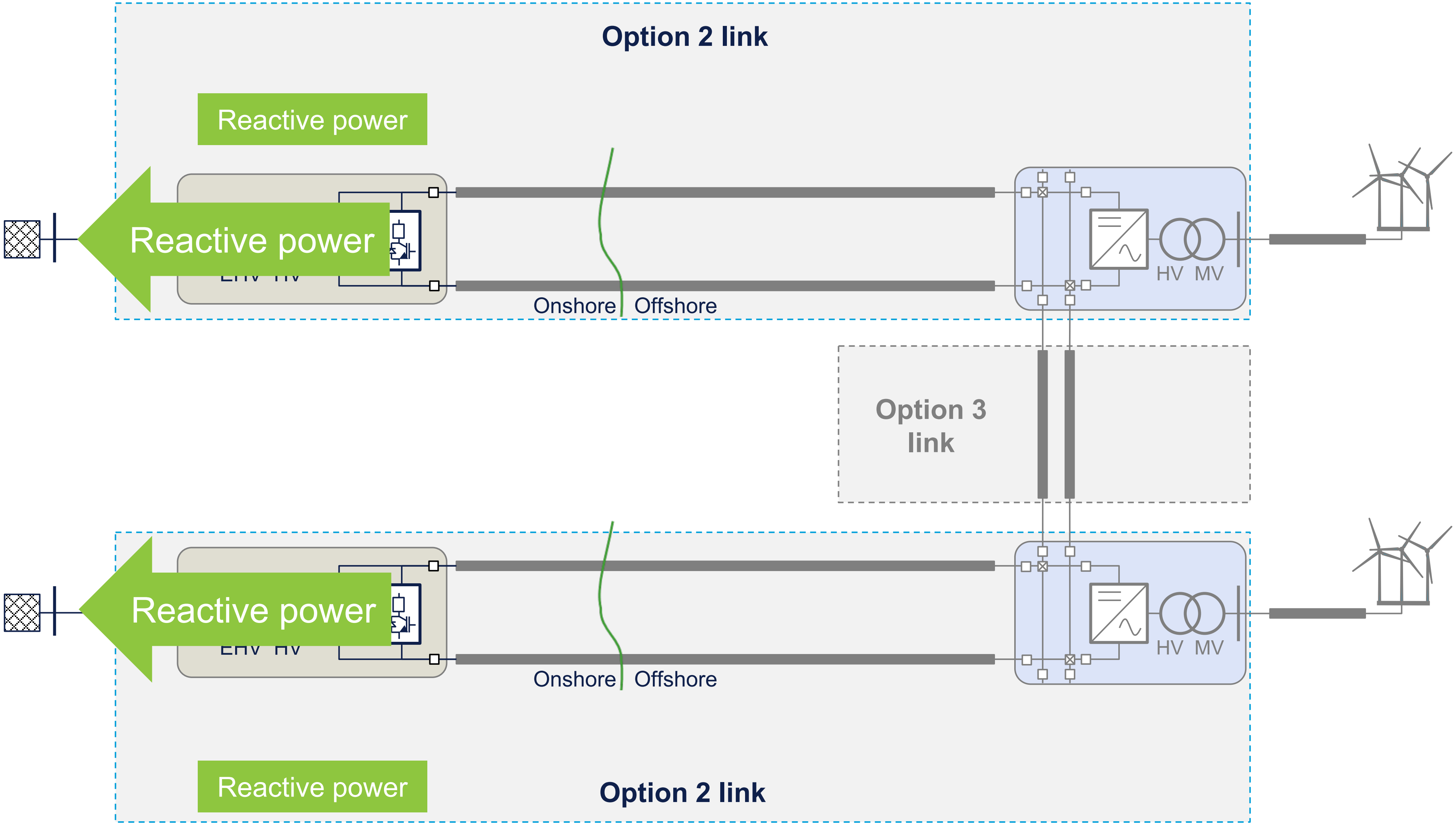
Control modes – Redundant transmission path



Control modes – POI Power exchange



Control modes – Statcom mode



Cost Benefits Appendix

Summary of Economic Analysis and CBA Findings

- **Comprehensive production cost and cost-benefit analysis performed for 28 OSW development pathways**
- **Pathways with interlinks perform better economically compared to pathways without interlinks.**
  - Interlink benefits quantified by Anbaric in the CBA capture economic benefits such as improved value due to reduction in EENT and reduction in the costs of the auxiliary generation required during outages
  - Curtailment reduction benefits and congestion benefits could significantly boost the economics of the interlinks in real-time operations, since studies have shown that curtailments are generally underestimated by over 50% in real-time compared to planning studies
- **Pathways with interconnection at Sewaren (Pathway 2 and 4) show significantly increased value to PJM than the corresponding scenarios with multiple OSW units connecting to Deans.**
  - Connection to Sewaren reduces onshore congestion experienced downstream of Deans POI
  - NPV of increased value of delivered offshore generation to Sewaren POI exceed $400 million in 2021 dollars averaged across multiple pathways.
  - NPV of Net Levelized Cost of Energy in pathways with OSW connecting to Sewaren is approximately $1/MWh lower than the scenarios with multiple OSW units connecting to Deans on average.

Cost-Benefit Assessment Approach

- **PJM and BPU methodology used in the assessment consistent with the principles of Manual 14B and Attachment A: NJBPU SAA Economic Evaluation Framework**
- **PROMOD benefits were calculated for the study years 2030, 2031 and 2033**
  - Benefits and costs inflated at inflation rate beyond 2033 study year
  - Study benefits were interpolated between study years and for 2028 - 2029
- **Project and Pathway Benefits**
  - NJ Gross Load Payments
  - Increased value of OSW generation – Calculated as the increase in the OSW generation revenue in certain pathways (Pathway 2 and 4) with alternate POI's compared to pathways with identical injection MW but injecting at SAA POI's.
  - Emissions benefits – Quantified and highlighted in the report. Not included in the CBA analysis
  - Interlink benefits (EENT and Aux Gen cost reduction)

Cost-Benefit Assessment Approach

- **Costs**
  - Option 1a costs were determined based on generation deliverability analysis and included in annual revenue requirement calculations of all pathways.
  - Onshore reliability upgrade costs (Option 1a) were evenly split over study years 2030, 2031 and 2033 (with appropriate inflation adjustments applied to the costs).
  - Pathways 5, 6 and 7 consist of alternatives for Option 2.4 (which can be substituted by 2.11) and 2.5 (which can be substituted by 2.12). However, Anbaric CBA analysis, as presented in the report tables, considers the higher cost options for the calculations. The lower cost options 2.11 and 2.12, if used, could lower the costs even further.

CBA Approach – Interlink Benefits

PROMOD simulations to determine the LMP values at OSW onshore POI's

Platform interlinks operated in Normally Open configuration i.e. interlinks only assumed operational during the period of outage of HVDC links to shore

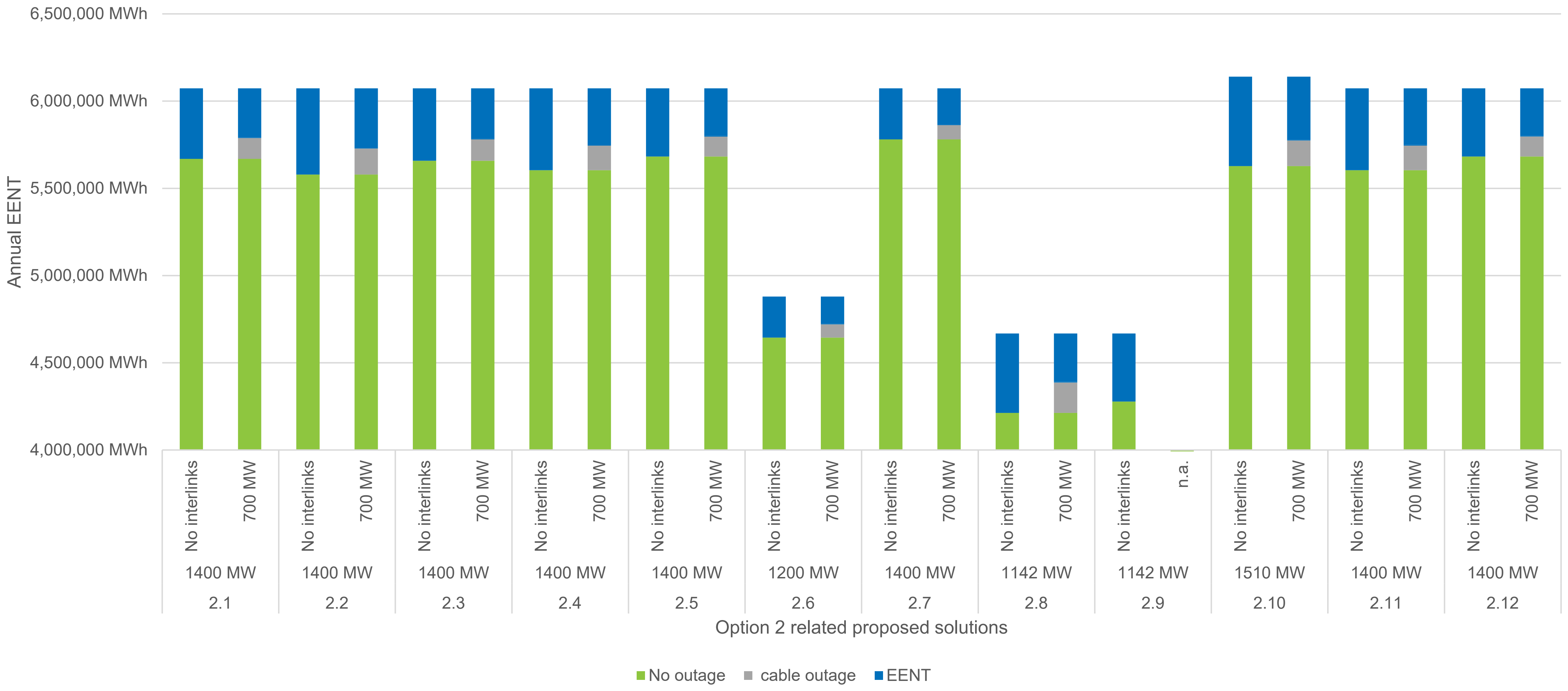
Unavailability Calculations – Expected Energy Not Transmitted (EENT)

- EENT for scenarios calculated based on Annual OSW Production (MWh) and Mean-Time-To-Repair (MTTR)

Total benefits Calculations

- Total benefits determined against the scenario without interlinks: *Additional EENT Revenue compared to no interlink scenarios ($) + Cost benefits of Auxiliary Generation during outage ($)*

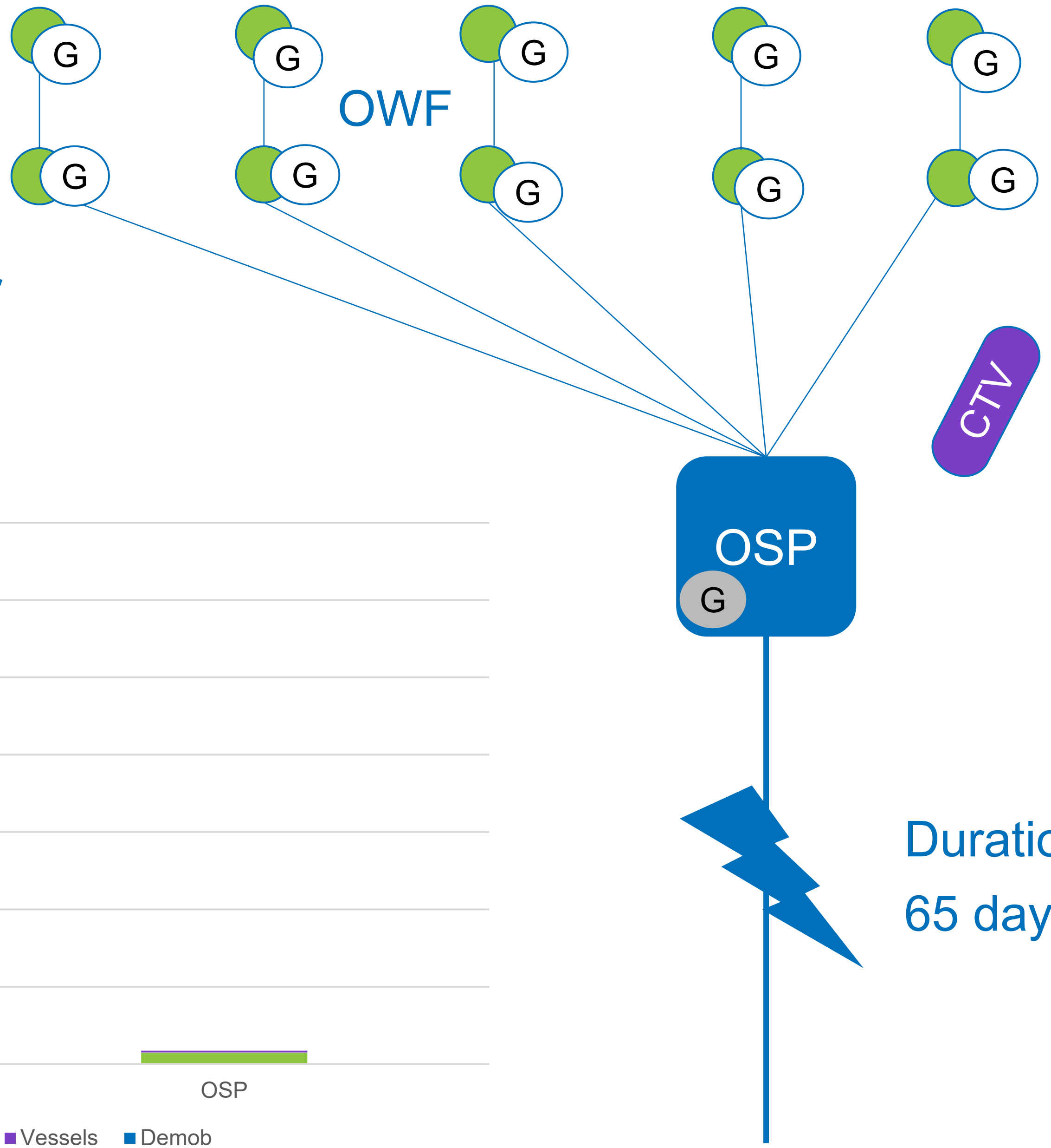
Energy Availability

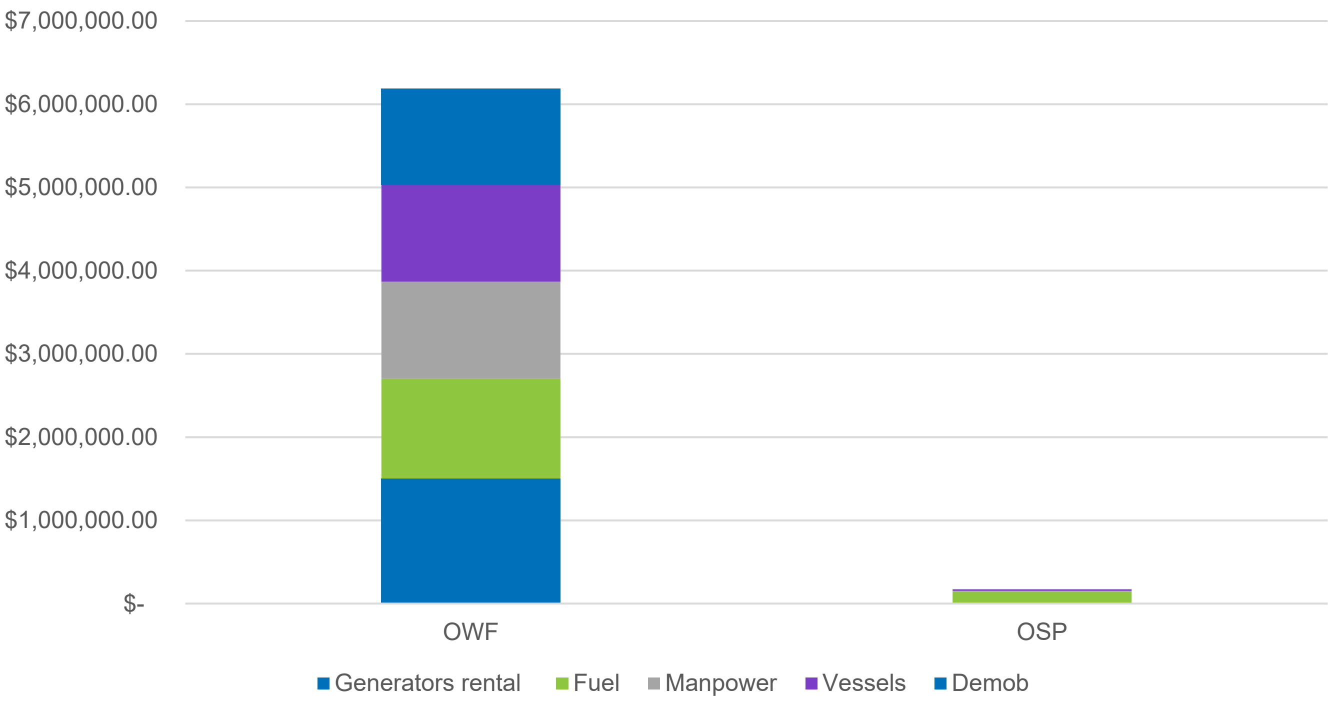


Auxiliary power

G Permanent diesel generator

G Temporary diesel generator





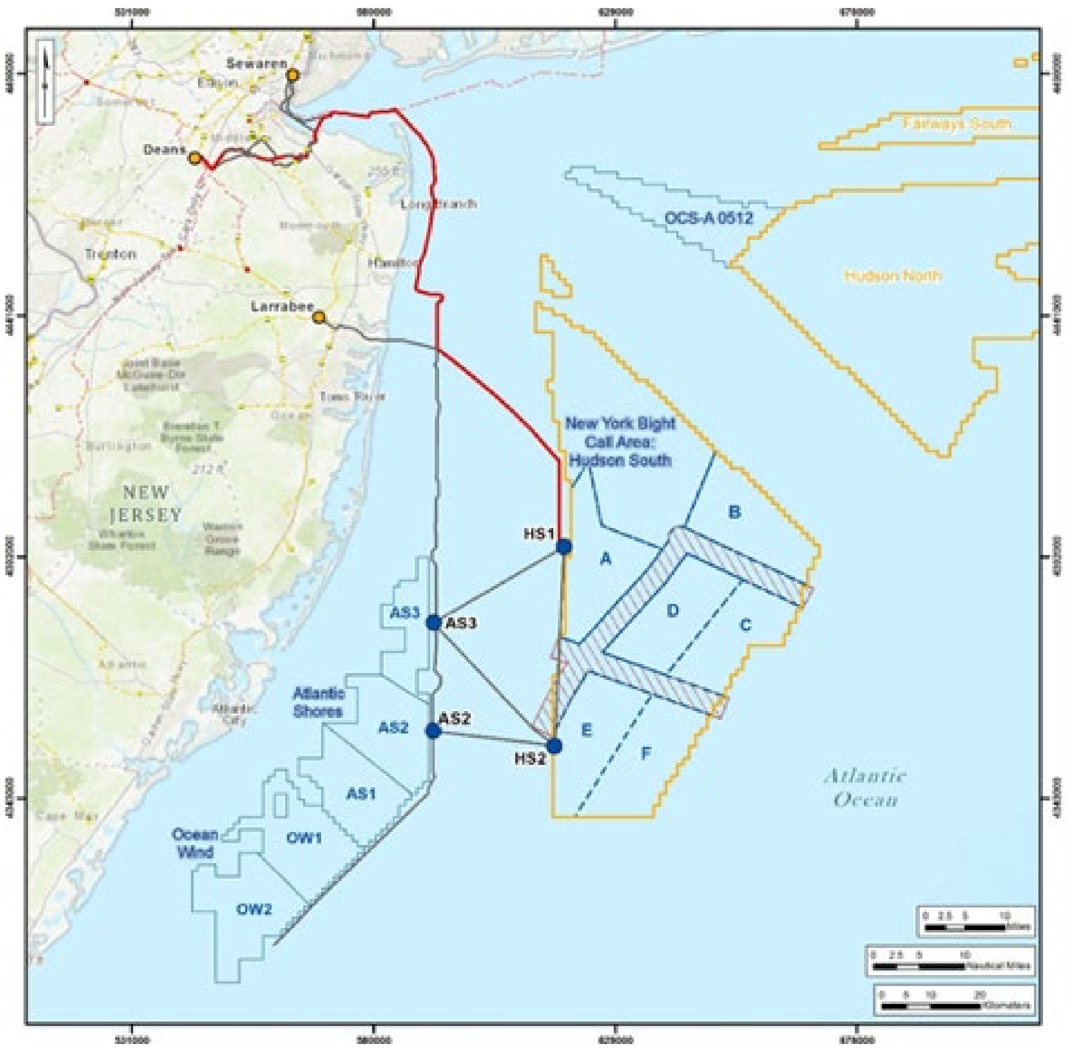
Duration of the repair
65 days

CBA Parameters

- **Base year: 2021**
- **Study years: 2030, 2031 and 2033**
- **Inflation Rate: 2.5%**
- **Discount Rate: 7.37% (PJM ME 2020 Process Scope, Sep 15 2020 TEAC)**
- **NLCOE**
  - NLCOE metric proposed by Anbaric factors in the costs of OSW generation and transmission needed to integrate varying levels of OSW into PJM footprint.
  - $NLCOE = \frac{NPV\ of\ (OSW\ Annual\ Rev\ Req + Offshore\ transmission\ Annual\ Rev\ Req - Total\ annual\ NJ\ benefits)}{Energy\ delivered\ to\ PJM\ grid\ (MWh)}$
- **Cost Benefit Analysis calculations presented by Anbaric in the Analysis Report uses Annual Carrying Charge Rate of 11.82% for transmission based on PJM Market Efficiency scope and input assumptions**
  - Cost caps and rate caps, as discussed in next section, were not factored into the CBA calculations.

Environmental and Permitting

- **Design and confirm**:
  - Offshore and onshore cable routes
  - Offshore substation platform locations
  - Landfall sites
  - Converter stations and Substations
- **Support Permit Applications**
  - BOEM Right of Way/Right of Use Grant or Easement
  - USACE CWA Section 10, 404 and 208 Individual permits
  - USCG Private Aids to Navigation Permit
  - NJDEP
    - In-Water Waterfront Development Individual Permit
    - Tidelands Utility License & Tidelands Dredging License
    - CWA Section 401 Water Quality Certification
    - Stormwater Permit
  - Local Permits



Environmental and Permitting

ANBARIC

- **Design and confirmation of routes and locations**
  - Detailed desktop analysis of environmental components
    - Offshore: Seabed bathymetry, Sediment types, Conservation areas, Subsea obstacles, Submarine infrastructure, Fishery zones, Navigational zones, Sand borrow areas, cultural resources.
    - Onshore: Road width, Existing infrastructure, Wetlands and water bodies, Sensitive habitats, Land use and zoning, Noise regulations, Cultural resources.
    - Sources included:
      - Publicly available data (BOEM, NJDEP, USCG, USGS and NOAA)
      - Third-party studies
      - DNV and other consultants' knowledge and experience

Environmental and Permitting

- **Design and confirmation of routes and locations**
  - Technical studies
    - Geotechnical and geophysical surveys:
      - Deans Converter Station
      - Marine Geophysical Investigation (Boardwalk Power Link)
      - Marine Geotechnical Investigation (Boardwalk Power Link)
    - Underground Utility Surveys (Poseidon Transmission Project)
    - EMF Study - AC and DC Land and Submarine Transmission Cable (Liberty Wind transmission system)
    - Baseline Sound Survey (Davidson Mill Road Converter Station - South Brunswick, NJ)

Environmental and Permitting

- **Environmental Protection Plan (EPP)**
  - Evaluate project activities and infrastructures to avoid and minimize potential impacts to physical, biological and socioeconomic components.
  - Resources evaluated for the selection of cable routes and the location of other infrastructure included:
    - **Physical resources:** Air quality, water quality, electric and magnetic fields, geological resources, airborne sound and under water acoustics, wetlands and waterbodies
    - **Biological resources**: Birds and bats, terrestrial wildlife, coastal and terrestrial habitats, benthic and shellfish habitats, finfish and essential fish habitats, marine mammals and sea turtles
    - **Socioeconomic resources**: Cultural resources (above-ground historic properties, and terrestrial and marine archaeology), visual resources, commercial and recreational fisheries, commercial shipping, land use and zoning, existing cables, tourism, public health and safety, workforce, economy, demographics, Environmental Justice populations.

Environmental and Permitting

- **Environmental Protection Plan (EPP) - General conclusions**
  - Impacts to sensitive terrestrial and marine resources will be largely avoided through informed siting.
  - When avoidance is not possible → minimization and mitigation measures based on industry best practices to manage risk of potential impacts.

Offshore	Onshore
Reduced water quality	Disturbance from airborne sound
Underwater sound	Reduced air quality due to dust
Increase in vessel traffic	Local traffic disruption
Disruption of commercial shipping	Tourism disruption
Disruption of commercial and recreational fishing	Public health and safety

  - Noteworthy negative potential impacts are temporary and reversible.
  - **Long-term positive impacts on regional workforce and economy**.

Environmental and Permitting

- **Fisheries Protection Plan (FPP)**
  - To ensure the appropriate management of potential impacts to commercial and recreational fisheries during Project activities.
    - Important commercial species:
      - Sea scallop
      - Menhaden
      - Atlantic surf clam
      - Ilex shortfin squid
      - Blue crab
    - Important recreational species
      - Striped bass
      - Summer flounder
      - Bluefin tuna
      - Bluefish
      - Thresher shark

Environmental and Permitting

- **Fisheries Protection Plan (FPP) - General conclusions**
    - Sources of potential impacts during construction:
        - Increased underwater sounds, increased vessel activity, seafloor disturbance, benthic habitat alteration, direct mortality or injury to fish species, sediment deposition, increased lighting, temporary displacement of fish species and fishing vessels from prime fishing grounds, and accidental spills/contamination.
    - Proposed minimization and mitigation measures based on most up-to-date industry guidelines and best practices:
        - Include measures developed by BOEM, NOAA, and the Mid-Atlantic Fishery Management Council
        - Examples: implanting a fisheries gear loss plan, using ramp-up procedures to reduce impacts from pile driving, and commitments for ongoing collaboration with third-party researchers to collect fisheries data following Project construction and installation.
    - **Anbaric is committed to continued informal and format communications and collaboration with stakeholders.**

Environmental and Permitting

- **Environmental benefits of Anbaric's HVDC offshore electrical transmission link**
  - Fewer impacts to fisheries, habitats, and sensitive resources
    - HVDC require 1/3 – 1/4 number of cables to interconnect the wind farm to land based transmission facilities compared to HVAC
    - Assuming: Five Offshore Wind Energy Areas (WEAs) in the NY/NJ Bight area
      Maximum buildout (1,200-1,400 MW) at each WEA

HVDC = 5 trenches

vs

HVAC = 15-20 trenches

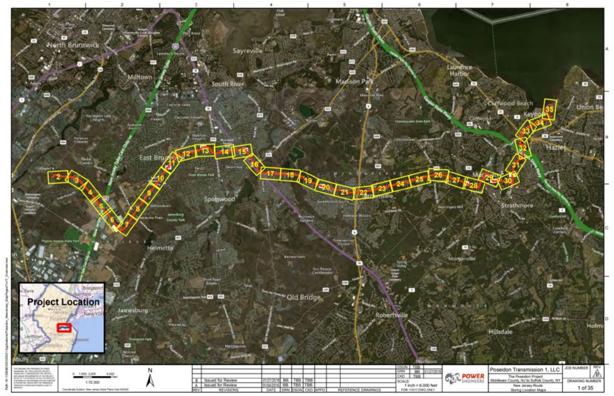
Environmental and Permitting

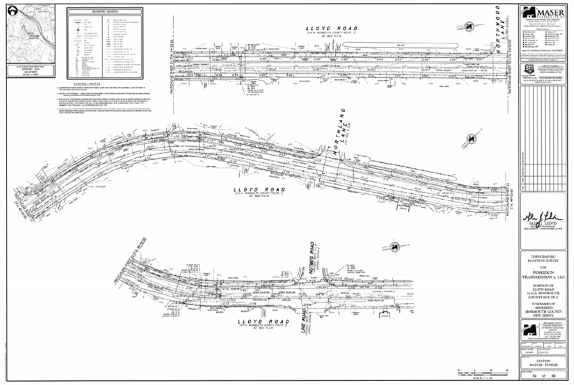
- **Environmental benefits of Anbaric's cable installation methods**
  - Fewer impact to communities, local residents and property owners, coastal and marine environments and aquatic resources
    - Use of **low impact methods** to install the submarine and onshore electric transmission links
      - Jet plow embedment methods for the submarine cable installation
      - Horizontal directional drilling (HDD) conduit installation at landfall sites and sensitive crossings
      - Use of public and private Rights of Way
    - Alternative methods of submarine cable installation (trench dredging and side-casting)
      - Results in removal of up to 5x more seabed sediment

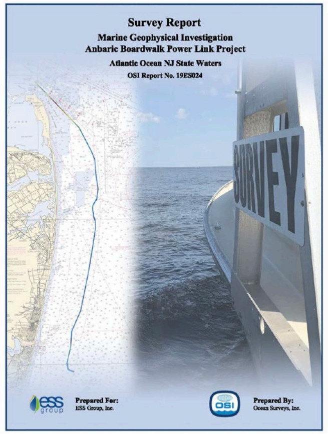
Projects at Deans 500kV Substation

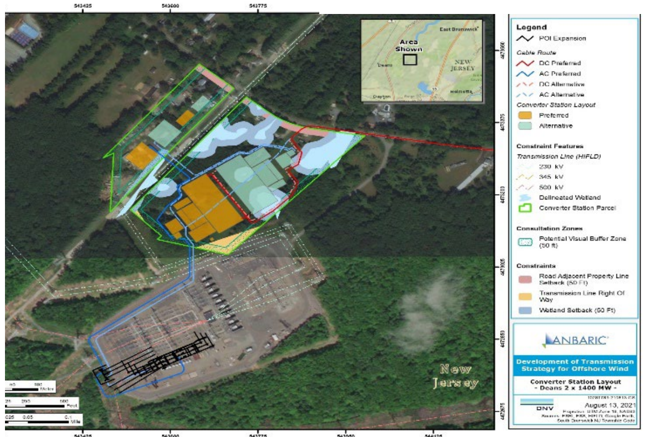
- Anbaric's history at Deans for its interconnection advantages which began in 2011 with the Poseidon Project a 500 mw HVDC link to Long Island with all interconnection's studies completed and executed ISA / ISCA in April 2015
- Anbaric acquired the rights to that project from then partner Exelon Corporation and continued to develop the project as an OSW injection into New Jersey known as the Boardwalk Power Link, a HVDC OSW transmission link into the Deans 500 kV substation
- Anbaric has completed the following:
  - Anbaric's land-based transmission route from Keyport to Deans in South Brunswick received NJDEP permits as follows:
    - Division of Land Use Regulation Permit • Freshwater Wetlands Permit • 401 Water Quality Certification • Waterfront Development Permit (Upland and In-Water) • Flood Hazard Area Permit • Federal Coastal Consistency Review
    - Permit No. 0000-17-0013.1 WFD170001 (IP In-Water), 0000- 17-0013.2 WFD170002 (IP Upland) and 0000-17-0013.1 FWW170001 (FWGP6), issued October 23, 201
  - Acquired site control via direct purchase and Option to Purchase Agreements
    - 25.54 acres adjacent to the Deans substation for up to two 1,400 MW HVDC Converter Stations totaling 2,800 MW including marine / land transition vault
  - Progressed rezoning of the property via the Town of South Brunswick Resolution for Area in Need for Redevelopment "Ordinance 2020-39: Adopting the "Davidsons Mill Road Redevelopment Plan" for the Area of 114 Davidsons Mill Road Located at Block 24, Lots 7, 8, 9, 10 and 12 approved November 24, 2020
  - Completed an underground utility survey for entire upland route
  - Upland route centerline drawings complete with crossings and splice vault locations , duct bank design complete
  - Preparing applications for easements for crossings
  - Collaborated with Town of South Brunswick Site regarding the architectural design
  - Substantial outreach with elected officials throughout the project's development
  - 100% underground transmission selected to minimize impact on local communities, and local opposition
  - Marine Geophysical and Geotechnical surveys complete
- The Boardwalk Power Link at Deans is an advanced stage of development and Anbaric is utilizing the same strategy for both Larrabee and Sewaren projects

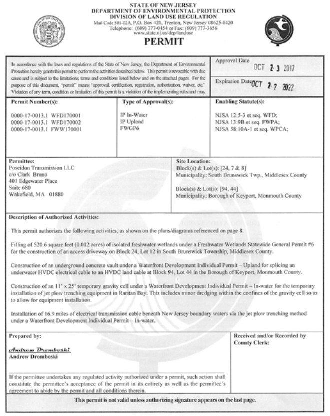
Projects at Deans 500kV Substation (cont)











STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF LAND USE REGULATION
Mail Code 501-02A, P.O. Box 420, Trenton, New Jersey 08625-0420
Telephone: (609) 777-0454 or Fax: (609) 777-3656
www.state.nj.us/dep/landuse

PERMIT

In accordance with the laws and regulations of the State of New Jersey, the Department of Environmental Protection hereby grants this permit to perform the activities described below. This permit is revocable with due cause and is subject to the limitations, terms and conditions listed below and on the attached pages. For the purpose of this document, "permit" means "approval, certification, registration, authorization, waiver, etc." Violation of any term, condition or limitation of this permit is a violation of the implementing rules and may

Approval Date OCT 23 2017

Expiration Date OCT 27 2022

Permit Number(s):	Type of Approval(s):	Enabling Statute(s):
0000-17-0013.1 WFD170001 0000-17-0013.1 WFD170002 0000-17-0013.1 FWW170001	IP In-Water IP Upland FWGP6	NJSA 12:5-3 et seq. WFD; NJSA 13:9B et seq. FWPA; NJSA 58:10A-1 et seq. WPCA;

Permittee:
Poseidon Transmission LLC
c/o Clark Bruno
401 Edgewater Place
Suite 680
Wakefield, MA 01880

Site Location:
Block(s) & Lot(s): [24, 7 & 8]
Municipality: South Brunswick Twp., Middlesex County

Block(s) & Lot(s): [94, 44]
Municipality: Borough of Keyport, Monmouth County

Description of Authorized Activities:

This permit authorizes the following activities, as shown on the plans/diagrams referenced on page 8.

Filling of 520.6 square feet (0.012 acres) of isolated freshwater wetlands under a Freshwater Wetlands Statewide General Permit #6 for the construction of an access driveway on Block 24, Lot 12 in South Brunswick Township, Middlesex County.

Construction of an underground concrete vault under a Waterfront Development Individual Permit – Upland for splicing an underwater HVDC electrical cable to an HVDC land cable at Block 94, Lot 44 in the Borough of Keyport, Monmouth County.

Construction of an 11' x 25' temporary gravity cell under a Waterfront Development Individual Permit – In-water for the temporary installation of jet plow trenching equipment in Raritan Bay. This includes minor dredging within the confines of the gravity cell so as to allow for equipment installation.

Installation of 16.9 miles of electrical transmission cable beneath New Jersey boundary waters via the jet plow trenching method under a Waterfront Development Individual Permit – In-water.

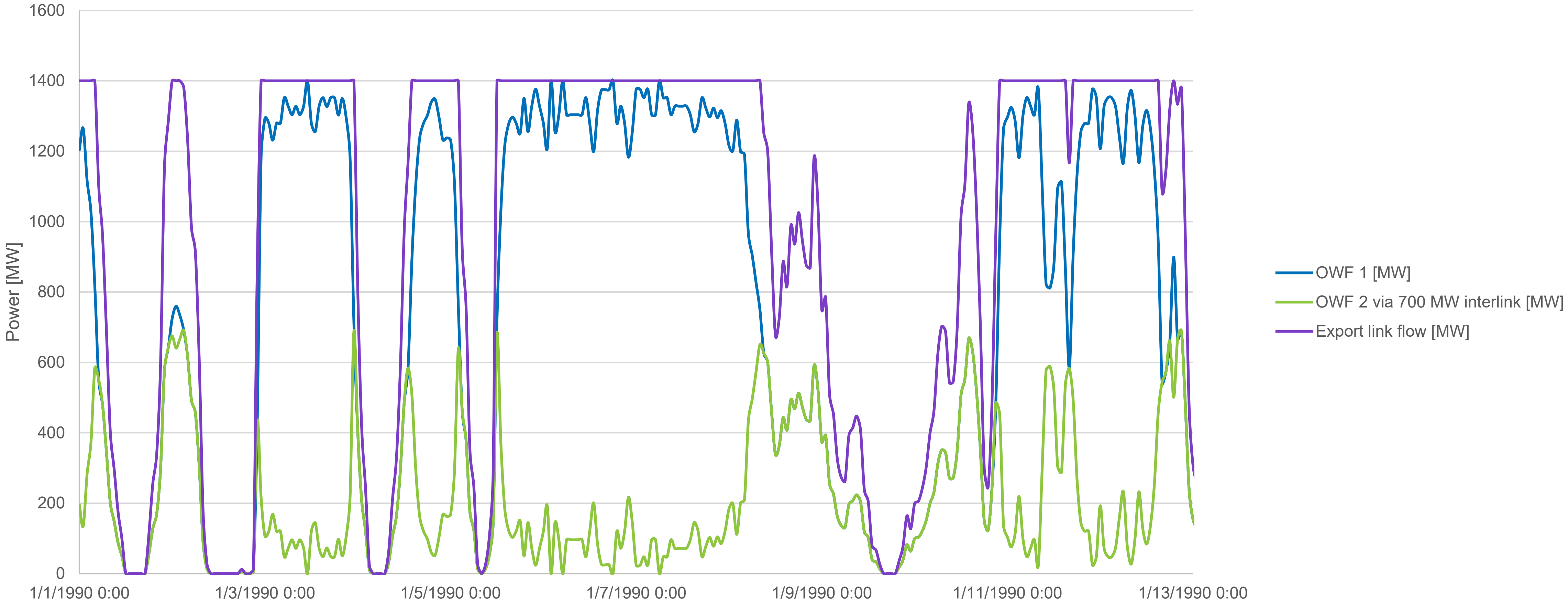
Prepared by:
Andrew Dromboski
Andrew Dromboski

Received and/or Recorded by County Clerk:

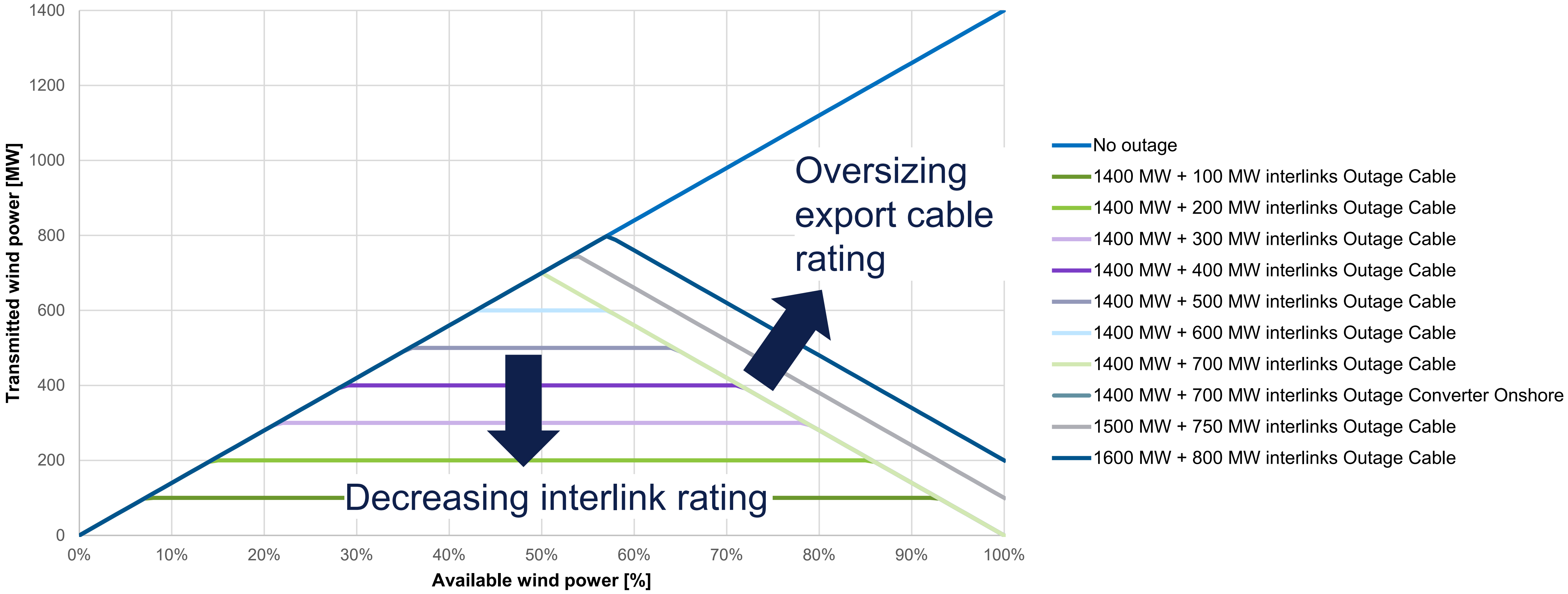
If the permittee undertakes any regulated activity authorized under a permit, such action shall constitute the permittee's acceptance of the permit in its entirety as well as the permittee's agreement to abide by the permit and all conditions therein.

This permit is not valid unless authorizing signature appears on the last page.

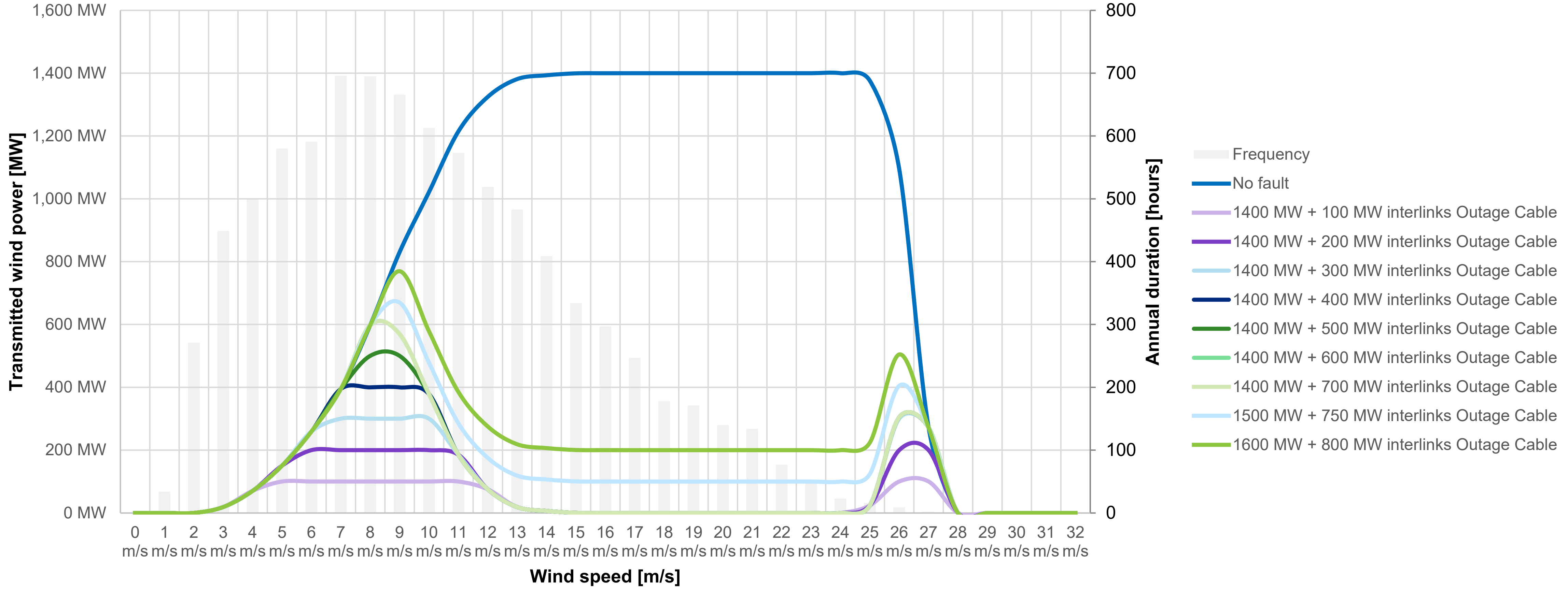
Export link loading



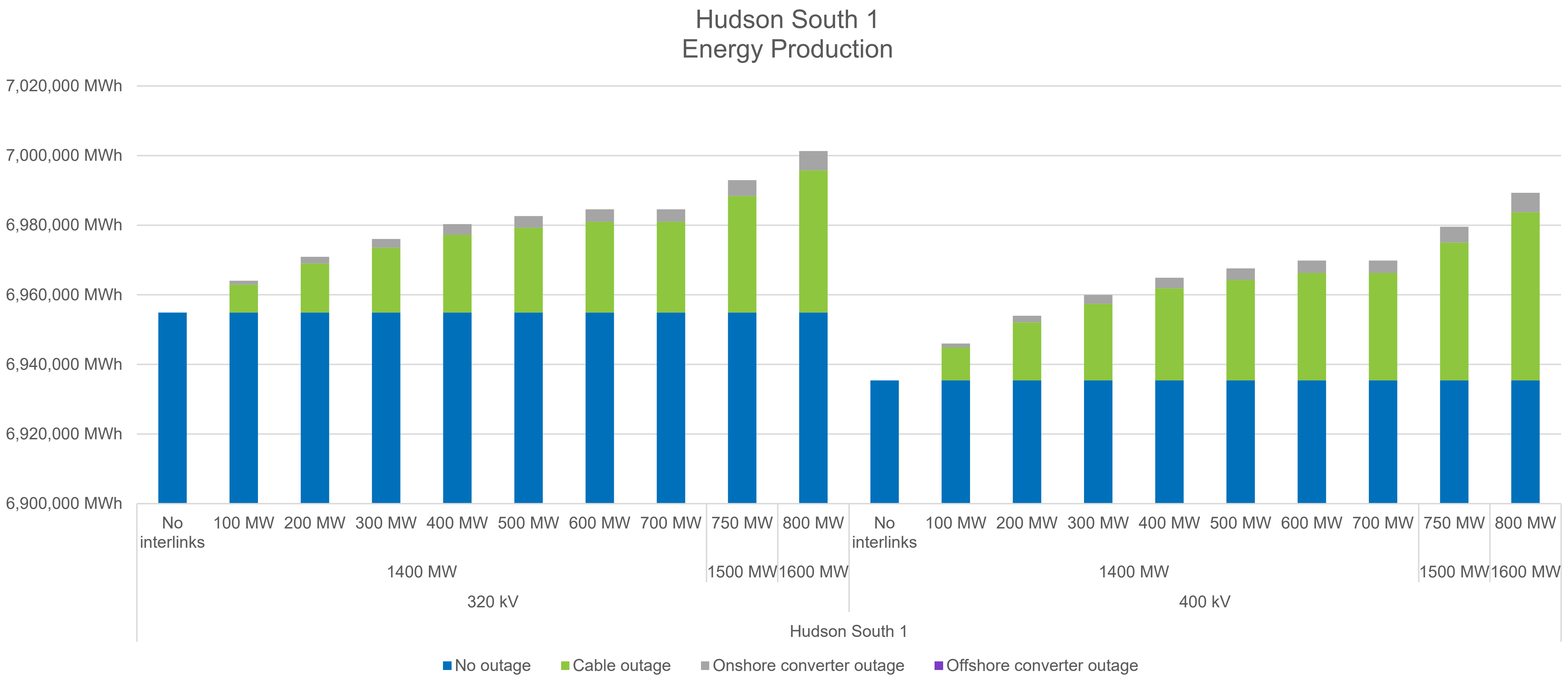
Transmission capacity curves



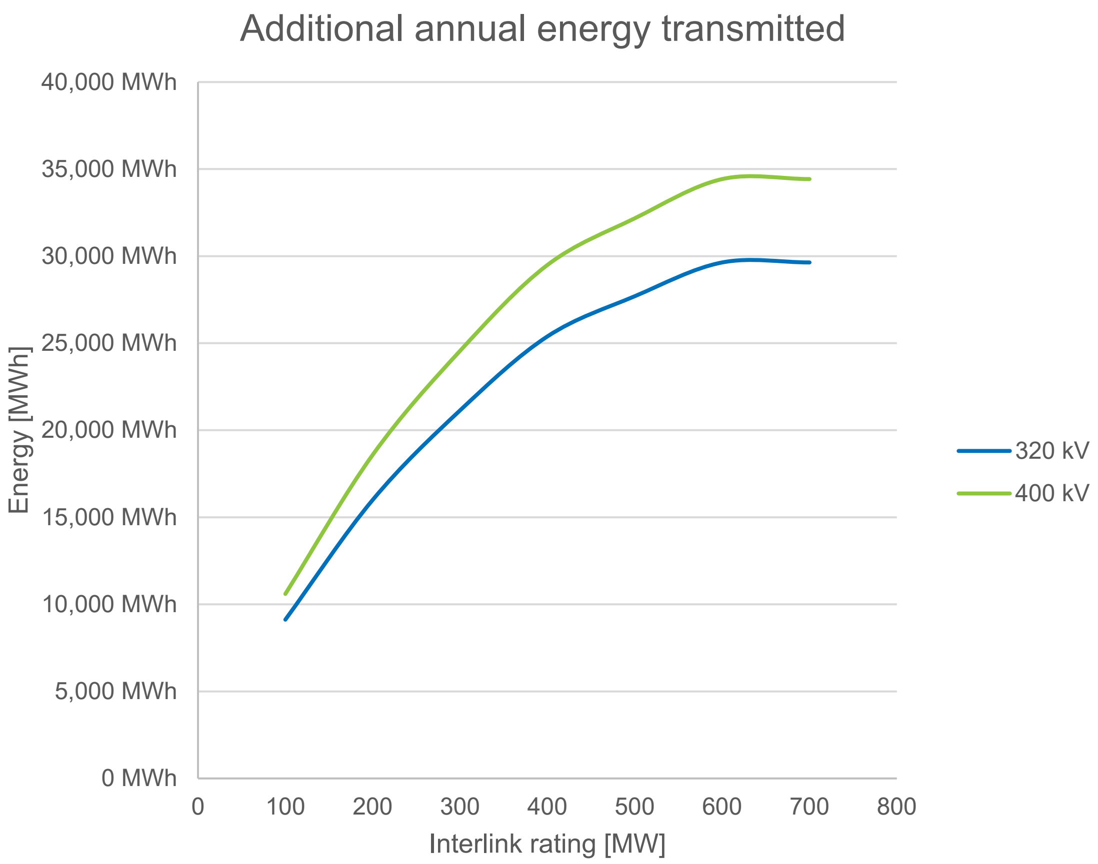
Generation/Transmission duration power curves

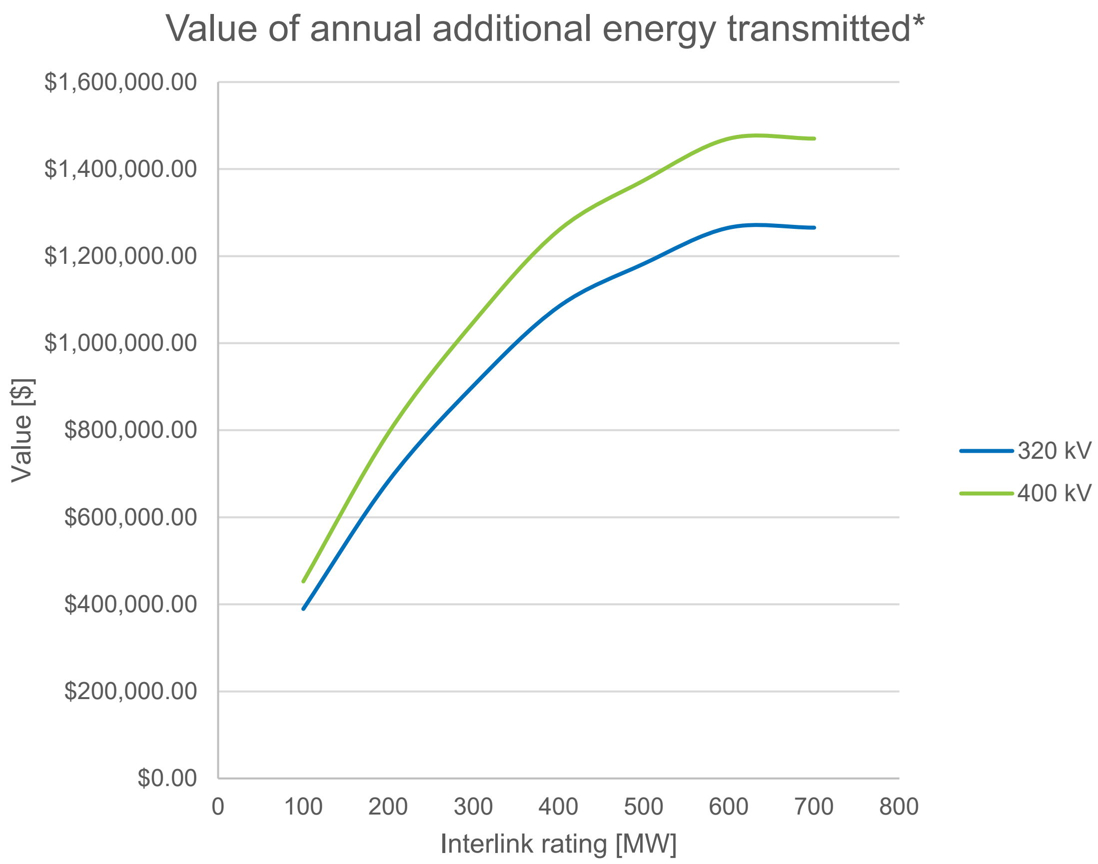


Benefit of Interlink vs Capacity



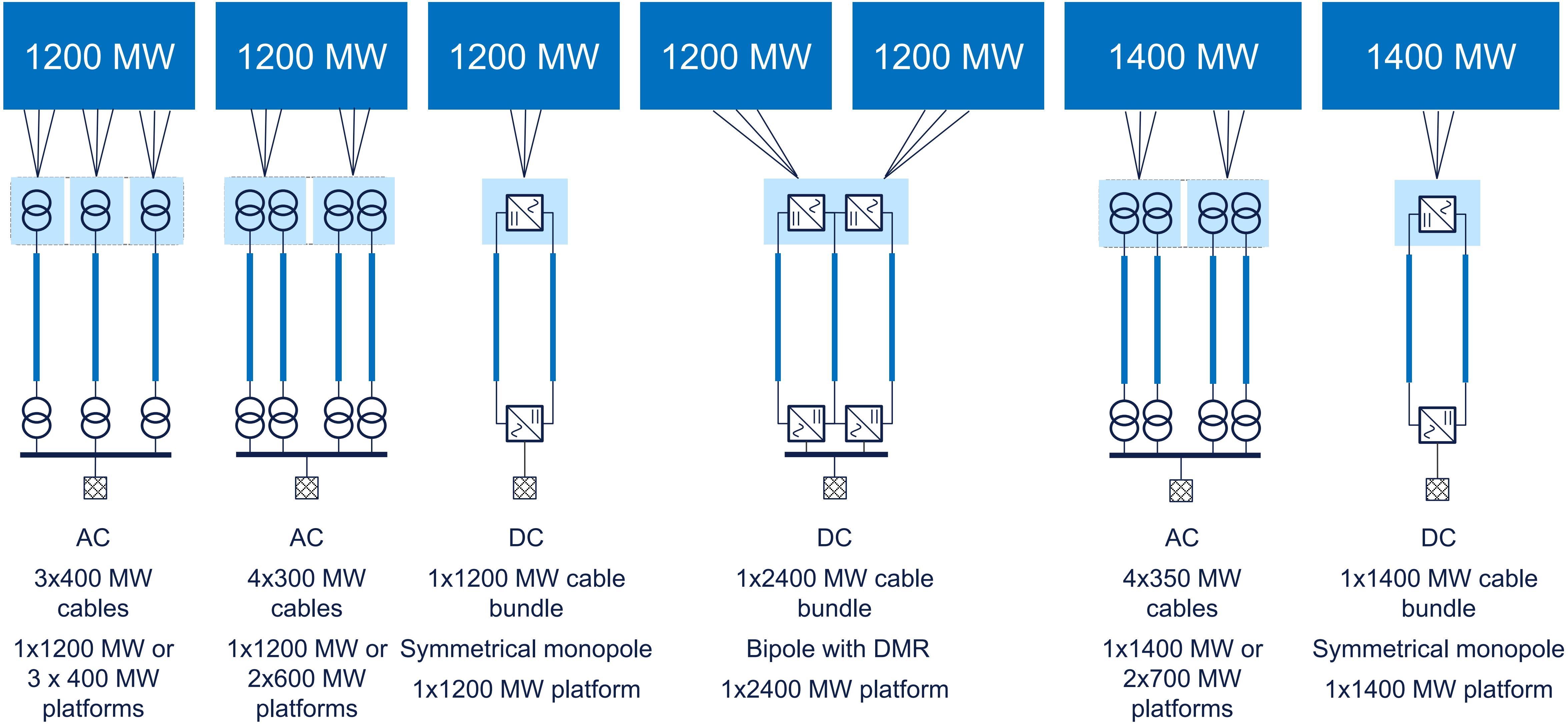
Benefit of Interlink vs Capacity



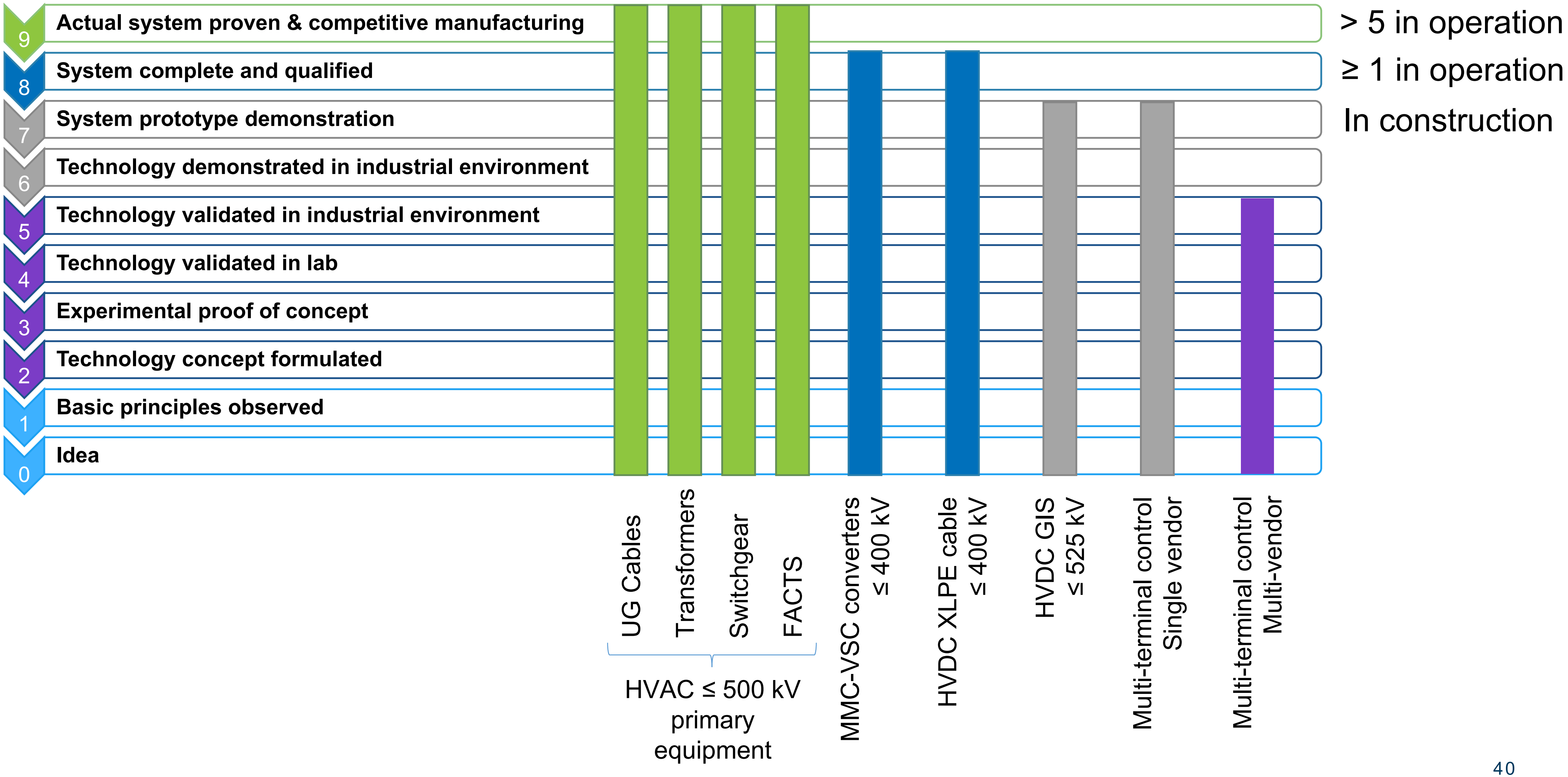


*Based on Load Weighted Average LMP for NJ = $42.70/MWh

Feasible solutions for option 2



Technology maturity



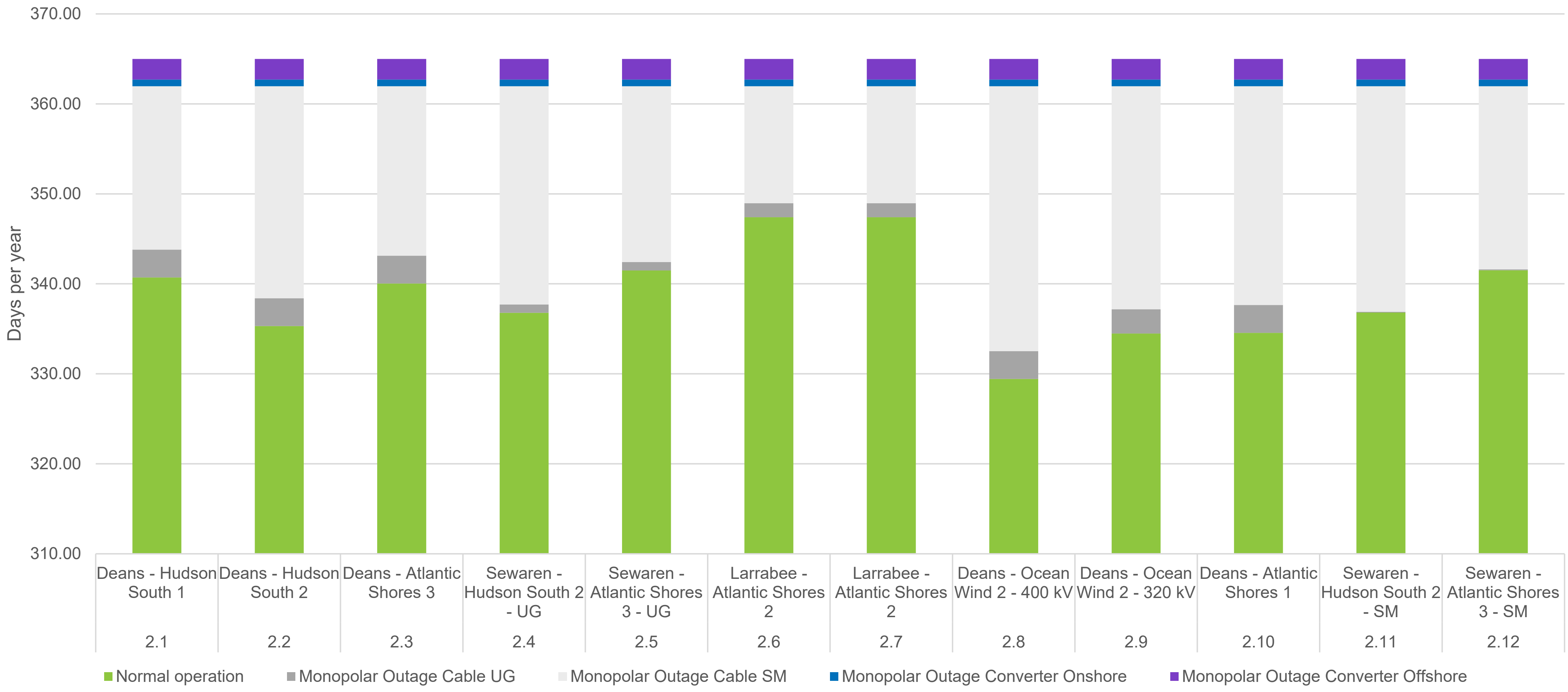
Environmental and Permitting

- Detailed desktop analysis for offshore route design included:
  - **Seabed bathymetry**: to avoid steep incline which complicates cable burial, installation, and repair.
  - **Sediment types**: to ensure that the transmission link can be buried to a suitable depth.
  - **Conservation areas**: to avoid and minimize potential impacts to Habitat Areas of Particular Concern.
  - **Subsea obstacles**: to avoid and/or plan for the presence of wrecks and obstructions, artificial reefs, disposal sites, and unexploded ordinance.
  - **Submarine infrastructure**: to avoid and/or plan for the crossing of existing or planned pipelines, communication/fiber-optic cables, utility areas, and charted submarine cables.
  - **Fishery zones**: to identify Prime Fishing Zones and assess/plan consultation needs.
  - **Navigational zones**: to avoid and/or plan for the presence of aids to navigation, anchorages, coastal maintained channels, and shipping lanes within which dredging may occur.
  - **Sand borrow areas**: The database of marine mineral resource leases helps to reduce or avoid conflicts with fishing, submerged infrastructure, shipping, cultural resources, sensitive habitats, and other such uses.

Environmental and Permitting

- Detailed desktop analysis for onshore route design included:
  - **Physical constraints**
    - Road width
    - Existing infrastructure (bridges, railways, etc.)
    - Wetlands and water bodies
  - **Biological constraints**
    - Sensitive habitats (Natural Heritage Priority Sites, Critical Wildlife Habitats, New Jersey Wildlife Management areas, National Wildlife Refuges)
  - **Human constraints**
    - Land use and zoning
    - Noise regulations
    - Cultural resources (historic buildings and known archaeological sites)

Average annual outage times



EENT Sensitivity study