

## Study Committee B3

Substations and Electrical Installations

Paper ID\_10902\_2022

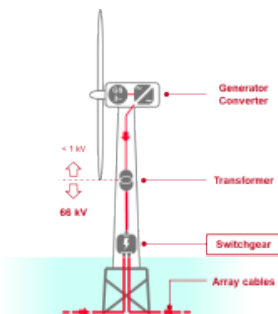
### A versatile and robust 66 kV switchgear for offshore wind tower

Ennio ERRICO

Hitachi Energy

#### Motivation

- Cost-effective extension of offshore wind farms is pushing towards the **increase of size and unit capacity** of the wind turbines, exceeding 15 MW. In this context, **66 kV has become the dominant voltage level** of the power collecting array.
- To protect the offshore equipment and enable maintenance operations in harsh environmental conditions, a **robust and reliable 66 kV wind tower switchgear** is required.
- **High versatility** is needed to meet increasingly **diversified mechanical and electrical requirements** from wind tower makers and end users.

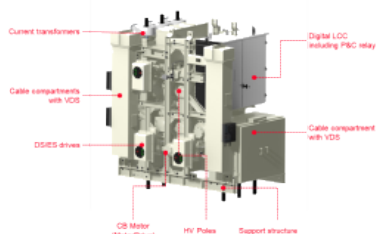


#### Objective

- **Design and test a new compact and robust 66 kV switchgear to meet different offshore wind tower requirements** in terms of mechanical integration, electrical and functional characteristics.
- **Inherit** existing components and features from well-proven hybrid switchgear platform with **20+ years field experience in the harshest service conditions**.
- Focus new developments mainly on peculiar components for wind tower applications: **Type-F cable bushings**, internal arc-proof cable compartments, **support frames**, etc.
- Achieve **best-in-class reliability** and maximum robustness, considering the specific challenges of the offshore industry in terms of onsite testing, **vibrations and shocks**, resistance to **humidity and corrosion**.

#### Results

- **Customizable 66 kV switchgear platform**, covering a wide range of mechanical, electrical and functional requirements.



- **Single-phase encapsulated** design to enable selective and cost-effective maintenance concepts, with **no risk of phase-to-phase internal faults**
- Designed and **fully type tested** according to the global high voltage standards **IEC 62271-1 and -203**, plus additional ratings and tests specifically required by the offshore wind industry

Rated voltage	72.5 kV
Rated current	2000 A
Rated short-circuit level	25 kA x 3 s
Frequency	50/60 Hz
Internal Fault protection	25 kA x 1s, IAC-A FLR (acc. IEC 62271-200)
Mechanical Endurance	M2
Operating temperature range	-30 / +50°C
Ingress protection	≥ IP55 (acc. IEC 60529)
Corrosion protection	C4 – High durability (acc. ISO 12944-2)

#### Pilot installation

- Installed since January 2022 in **China's first ever 66 kV offshore wind farm, Huadian Yuhuan Phase 1**, consisting of N°22 wind turbines with a total installed capacity of 154 MW.



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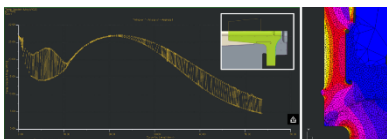
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# A versatile and robust 66 kV switchgear for offshore wind tower continued

## Design & development

- The development was managed by an **international team of experts** in different disciplines, following a proven **gate-stage R&D process**, and adopting **state-of-the-art tools**.
- The **primary components** are mostly derived from pre-existing products with **higher ratings** in terms of nominal voltage, nominal current and short-circuit current.
- New components like the Type-F cable bushing have been developed through **consolidated simulation tools and acceptance criteria**, embedding **adequate safety margins**.



## Testing

- Full set of type tests according to IEC 62271-203:** Dielectric (LIWV, PFVV), PD measurement, Mechanical endurance, Low & High temperature, Temperature rise, STC, IP, etc.
- VLF voltage test**, acc. IEEE 400.2-2013 for 69 kV rated voltage: **119 kV, 0.1 Hz, 60'**
- Vibration tests** on full-scale switchgear
  - 1 ÷ 80 Hz, 0.54g (RMS) x 2.5 hours, tri-axial mode
  - Additional, sinusoidal sweep test with constant acceleration of 10 m/s<sup>2</sup> on each axis



- Corrosion and Humidity tests**

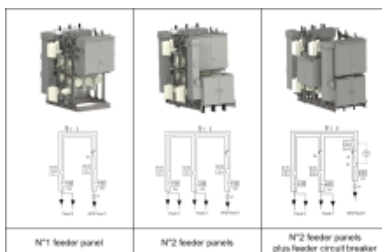


## Configurations

- Modular product structure** and **tailored design approach** make possible to adapt the switchgear to multiple configurations.
- Possibility to achieve a **wide variety of single-line diagrams (SLD)** and optimized layouts.
- Typical **primary panels** of the wind tower switchgear:

Type	WT Panel	Feeder Panels
Q.ty	1	1, 2 or 3
Connected to	WT power transformer	Subsea array cables
Standard functionalities	CB, DS/ES, CT, VDS	DS/ES, VDS
Optional functionalities	-	CS or CB, SVT

- Examples of configurations:



## MotorDrive

- Circuit breaker drive based on a **digitally controlled servo-motor system**, consisting of a brushless motor directly fit on the transmission shaft, while the energy is stored in capacitor banks.



- ✓ **Maximum mechanical reliability** thanks to minimum number of moving parts
- ✓ **Real time self-monitoring** detecting any malfunctioning in advance, to allow failure management strategies and **maximize availability**
- ✓ Minimum noise level