

Introducing EcoSwing

Energy Cost Optimization using Superconducting Wind Generators

Our Ambitions



Superconductivity has matured sufficiently that we can follow an ambitious plan:

- Design, develop and manufacture a full scale multi-megawatt direct-drive superconducting wind generator
- Install this superconducting drive train on an existing modern wind turbine in Thyborøn, Denmark (3.6 MW, 15 rpm, 128 m rotor)
- Prove that a superconducting drive train is cost-competitive.

“EcoSwing aims at nothing less than world's first superconducting low-cost, lightweight drive-train demonstrated on a large-scale modern wind turbine”

Technology Approach



- **Generator:** Synchronous
 - **Drive Train:** Direct Drive
 - **Superconductor:** 2nd Generation
 - **Refrigeration:** Closed Cycle
 - **Power Converter:** Full Power IGBT
- 40% weight reduction compared to a Permanent Magnet generator!

Platform for Technology Validation



- The idea is to replace a PM generator with a superconducting generator

Direct Drive Generator } Drive Train
Full Power Converter }

- This includes power conversion and refrigeration equipment.

Integrated Consortium

- 9 Partners from 5 countries working for a common goal
- EcoSwing is led by an end-user. It represents a wholly integrated supply chain from materials to the end-user.



UNIVERSITY OF TWENTE.



Key Project Figures



- **Program:** EU Horizon 2020
- **Reference:** 656024
- **Start Date:** 2015-03-01
- **End Date:** 2019-03-01
- **Total Cost:** EUR 13,846,594
- **EU Contribution:** EUR 10,591,734

- The project is currently in the advanced design stage.

- Monitor our project web site for updates: www.ecoswing.eu

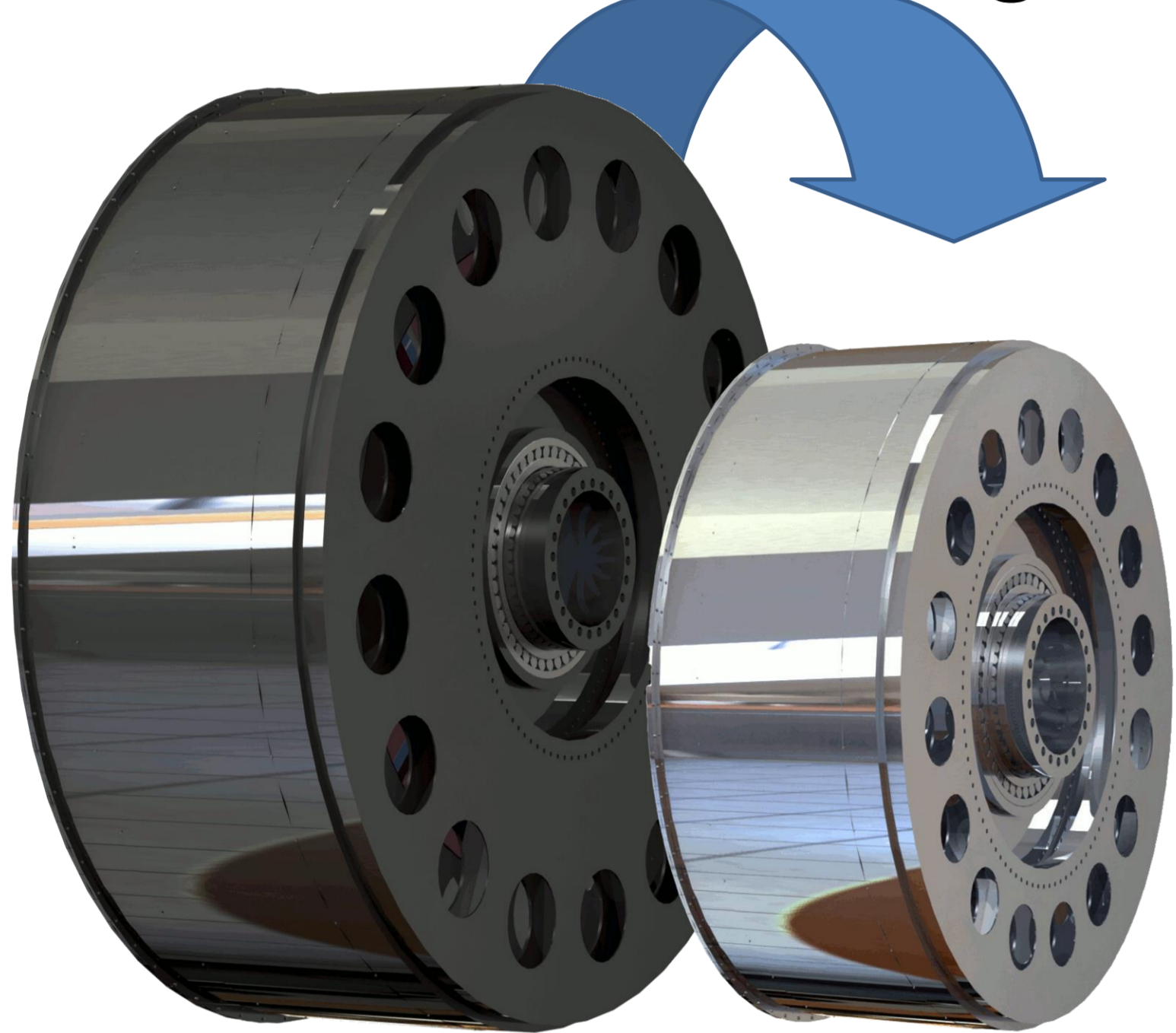
“EcoSwing has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 656024.”
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EcoSwing First Results

Accomplishments after 6 Month of Project Work

Design

40% lower weight



PM

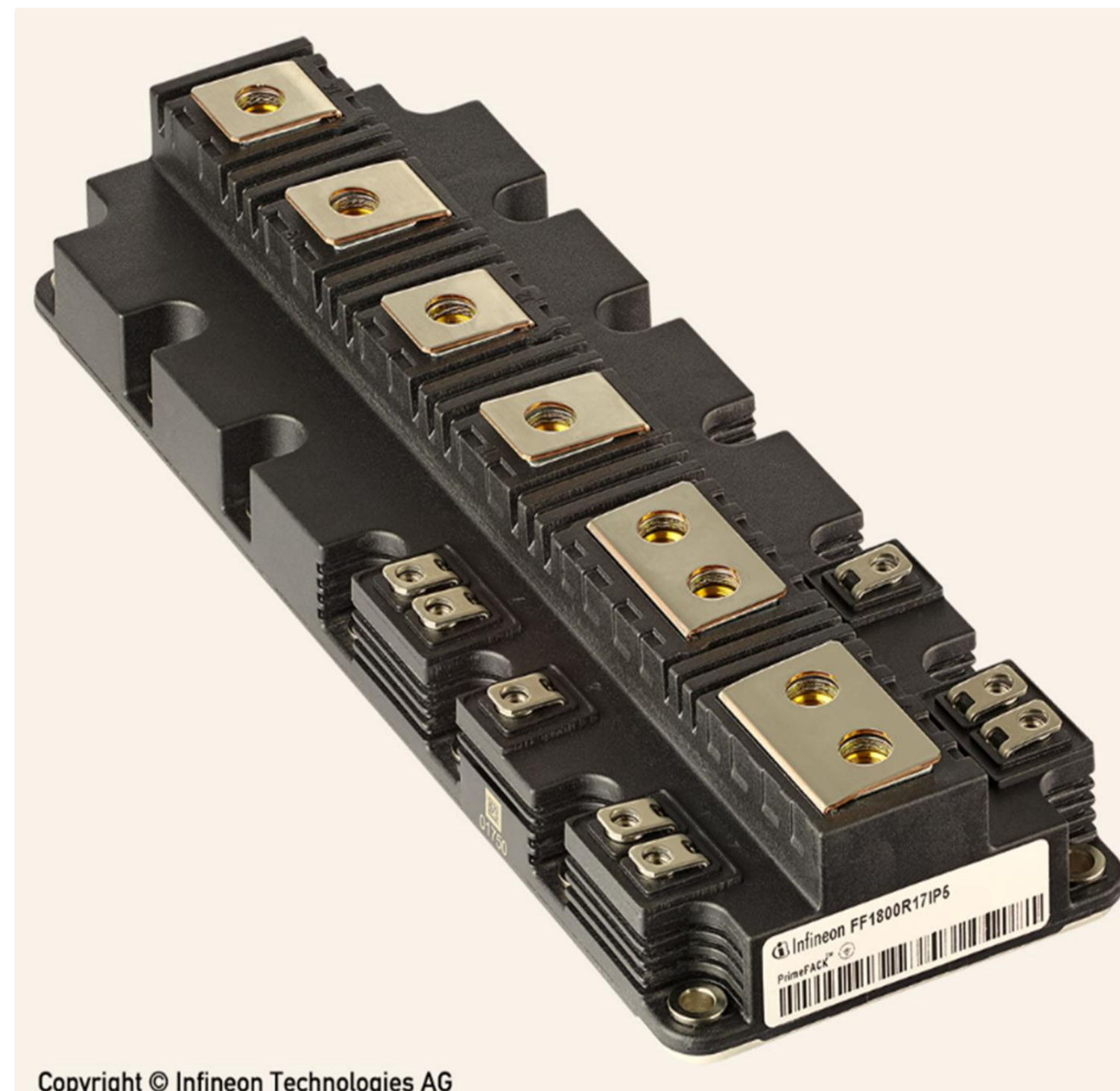
Superconductor

- JEUMONT and ECO 5 finalized a innovative design approach
- **All roads capability:** We limit the diameter to < 4 m
- **Low cost design:** 'No frills' for superconductors
- **Low weight design:** Optimized for low top head mass
- **Mainstream markets:** 3.6 MW for onshore and offshore
- This design is currently being verified and detailed.

“Superconductors clearly have the potential to be a key enabling technology of the 21st century.

Now the technology has matured sufficiently to go one step further to a relevant demonstration in the field of renewables”

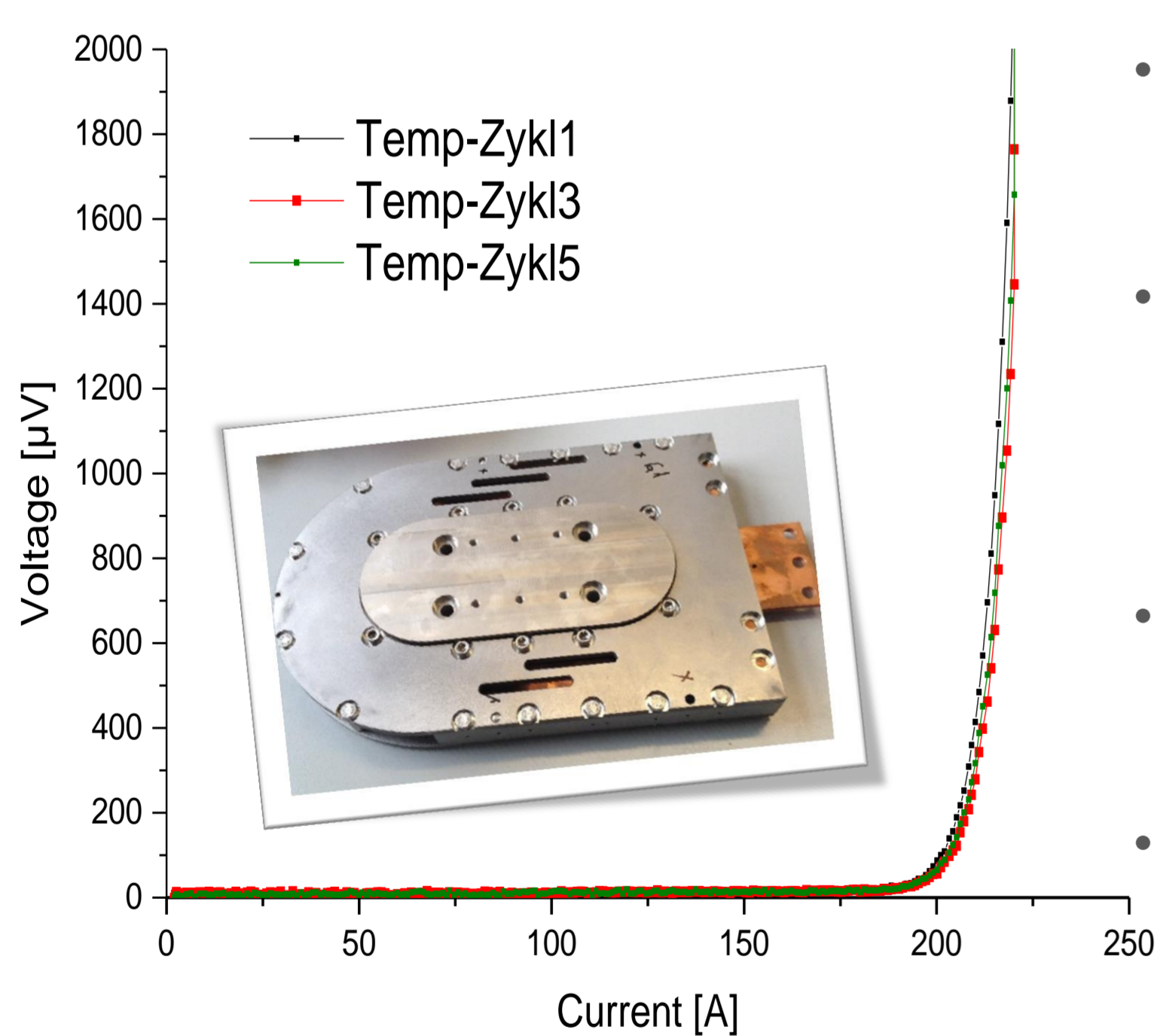
Power Converter



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- DELTA provides the power converter
- New IGBT module family allows
 - using 1800A PrimePack3+ in the same footprint
 - to develop a power stack capable of > 1MVA in the same compact design even at very low generator speed
 - cost effective standard liquid cooling
- DELTA also addresses DAQ and quench protection.

Superconductor



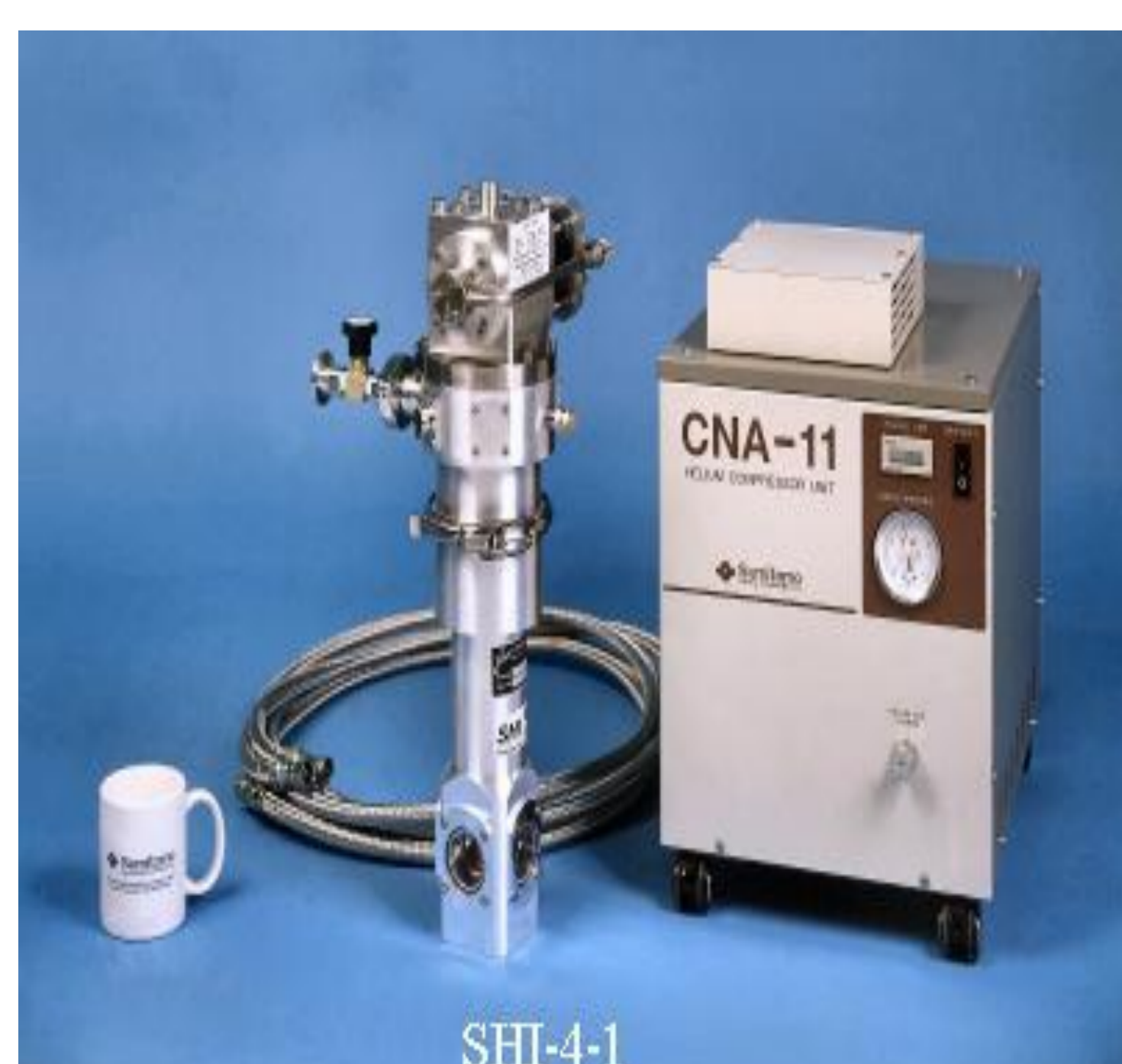
- THEVA provides the rotor coils— type testing is done by UTWENTE
- Superconductors offer
 - 100 x the current density of copper
 - Practically no Ohmic losses
- We plan to have ~100 mV (!) of drive voltage on the entire rotor
- Superconductors showed practical lifetimes > 30 years without aging.

Ground Based Test



- Fraunhofer IWES will execute tests in its Bremerhaven DyNaLab
- Most advanced testing facility
 - Max torque 13 MNm
 - Max power 15 MW
- Test will include nominal power tests and short circuit testings
- DNV GL will provide pre-certification support
- Then ENVISION will install the superconducting drive train on an existing modern wind turbine in (3.6 MW, 15 rpm, 128 m rotor)

Cooling



SHI-4-1

- SHI CRYOGENICS will adapt commercial cooling appliances
- Interesting facts
 - The refrigeration is closed cycle
 - Only 12.5 grams (!) of refrigerant
 - The cooling devices will spin with the rotor
- These cryocoolers are built in 1000s per year and can be found in many industries.

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