EcoSwing : the Learnings

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Core ambitions

- 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

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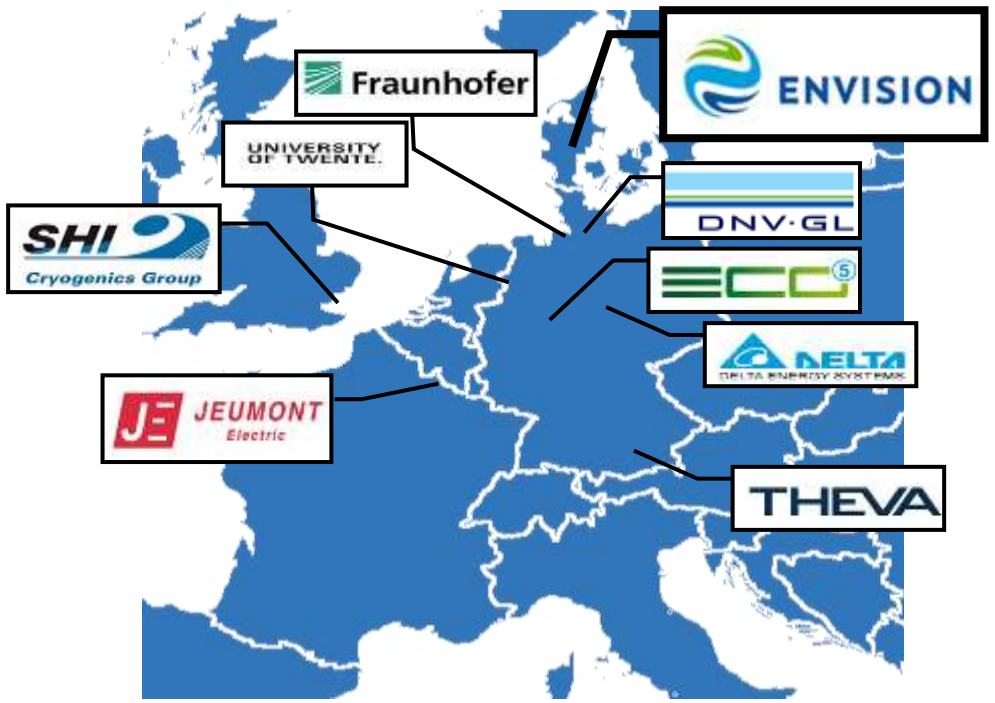
The consortium



- 9 Partners from 5 countries working for a common goal
- Envision is coordinating one of the currently biggest superconductivity project world-wide
- This project has attracted an EU Contribution of EUR 10,591,734.

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Major choices

- Second generation HTS wire
- Conduction cooling by commercial cryogenic equipment, except the rotating Helium seal
- Conventional stator (air cooled)
- Superconductive rotor

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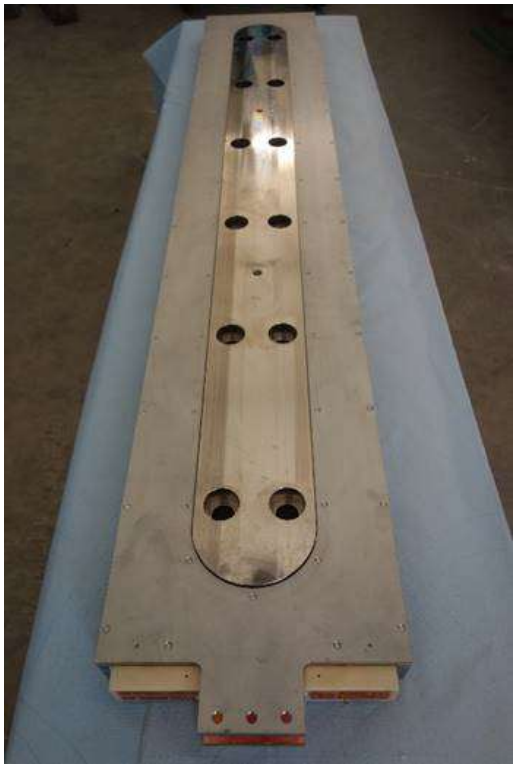
Superconducting coils

- 500 m of high performance superconductor
- Potted using commercial resin, glass fiber reinforced
- Steel package for bolt mounting
- Operating temperature ~30 K (-240 °C)
- Conduction cooled with cold heads.



THEVA

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Assembly at Jeumont Electric

Stator, superconducting rotor, full converter – Dec 2017

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On IWES Fraunhofer testbench
Installation on the DynaLab - March 2018

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On ENVISION site in Thyboron

Replacement of PM machine (left) by superconducting generator (right) – End 2018

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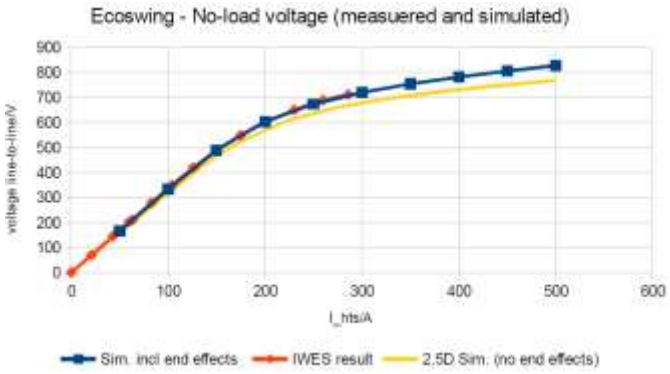
Ecoswing : lessons learnt

The machine operated six months on the wind turbine.
We experienced two times IGBT main inverter failures and we could reached 3MW. Therefore the generator experienced huge transients phenomena without damage.

→ **Experience is in accordance with calculations**
→ **The target is reached. The SC machine ran long time in real environment without failure**
→ **The generator is very robust**



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Ecoswing : lessons learnt

The SC rotor got a failure in IWES due to defective pole :

- The quench protection detection system detected it and protected the machine. It enabled the machine to run at 30% of rated power in IWES with defective coil
- The airgap flux sensors signals analysis revealed before the quench that an interturn short circuit happened
- The pole could be easily exchanged after IWES tests and before installation on the wind turbine

→ **The quench detection is effective**
→ **Machine can run in degraded mode even with defective SC pole**
→ **Repair of the machine was fast and not tricky operation**

Defective pole

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Ecoswing : lessons learnt

Cryogenic equipment ran perfectly in real operation for six months :

- Rotor cooling didn't fail
- Most of equipment are on the shelf ones
- The developed Helium rotating seal functioned perfectly.

→ The cryogenic equipment to operate such a superconductive machine is ready

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Ecoswing : lessons learnt

The superconductive wire was not in mass production in the beginning of the project.
Coming to mass production (there is 20kms of SC wires in Ecoswing) was a challenge for our partner Theva.

→ **superconductive wire is now ready to be used in huge electrical machines.**
→ **Cost of wire is still too high to make SC machines competitive**
→ **Mass production of such a wire is a technical and industrial challenge.**
→ **Some efforts have still to be done**

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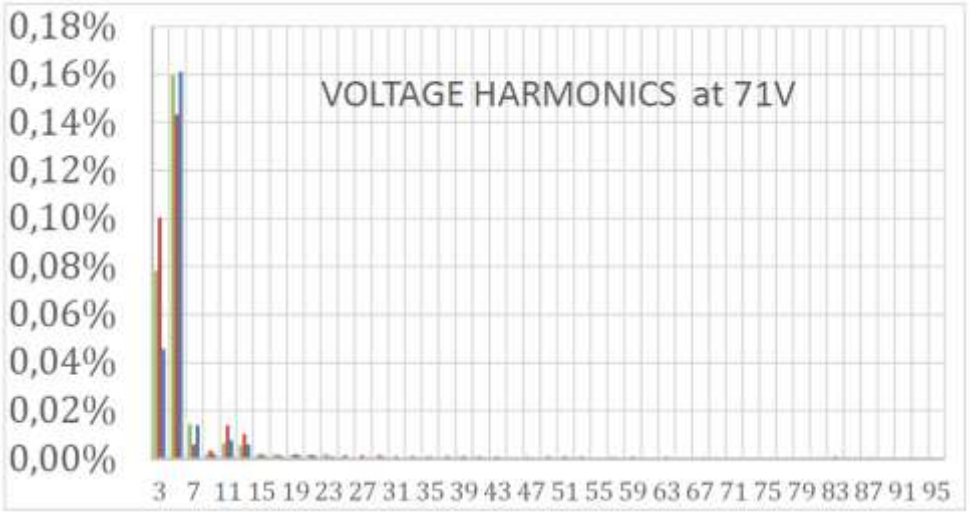
Ecoswing : lessons learnt

No special features were taken to reduce harmonics (straight stator teeth, low slot number) ; however because of huge airgap on SC machine, harmonics levels are very low.

→ SC machines have a huge potential of discretion

→ It should be a nice solution in application in which it is relevant (propulsion, …)



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Ecoswing : lessons learnt

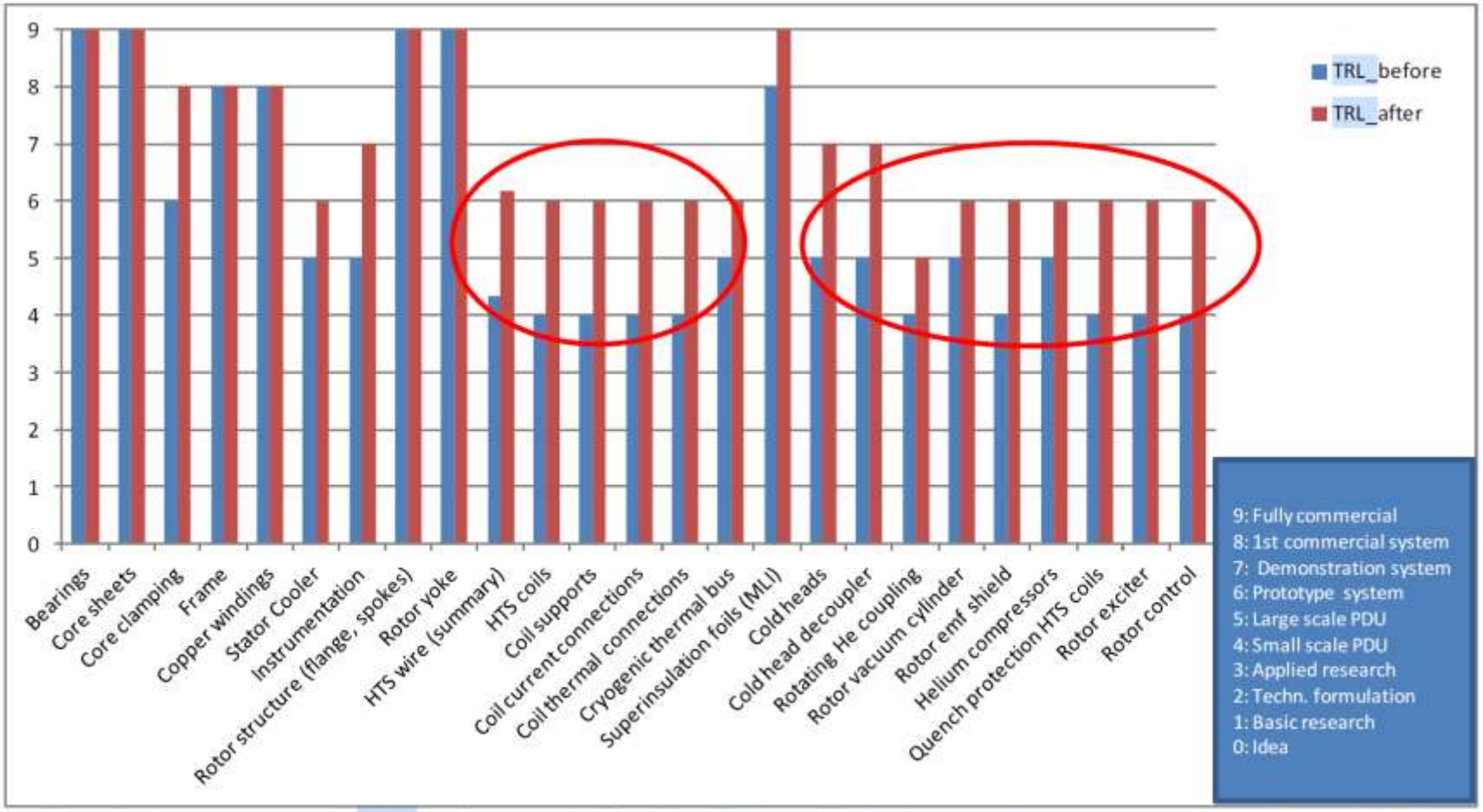

Fig. 3: Assessment of TRL before and after EcoSwing. Major impact areas are encircled in red. This figure was made during proposal writing. It is part of the Technical Annex of the GA (fig 9., page 11)

Marketing benefits

→Superconductive machines are going out of laboratories

→Compactness + weight reduction + huge power ratings = opportunities in Marine, Navy and Aero sectors

→Impact of overall cost of installation

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Conclusion