Pseudo magnetic direct drive (PDD) vs superconducting (SC) generators

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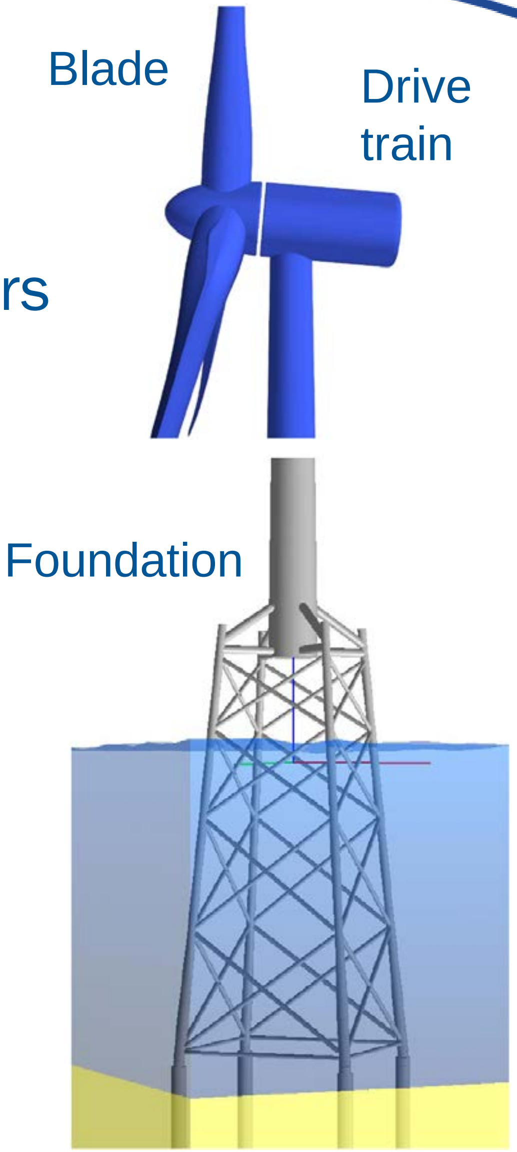
Outline

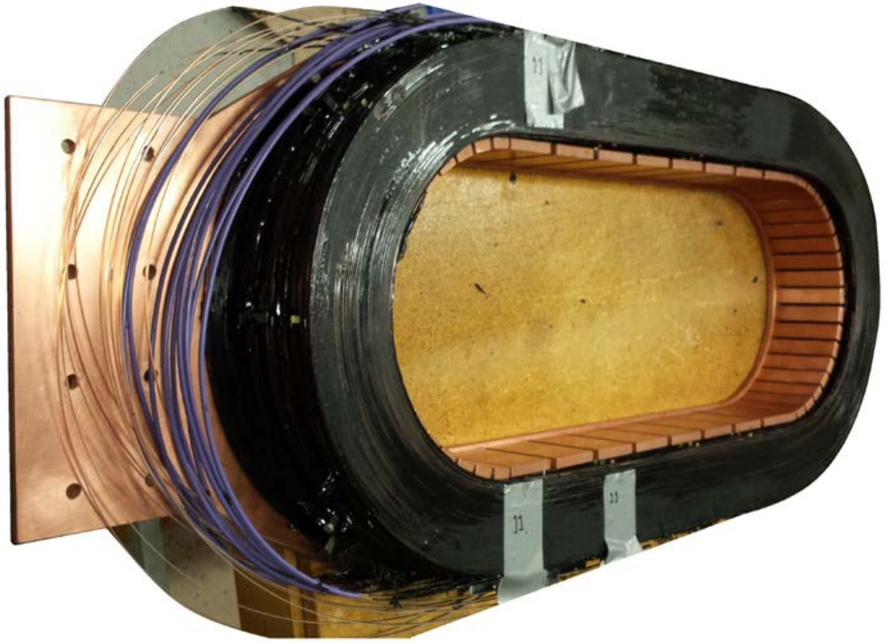
Non-contact drive trains for 10 – 20 MW

- Superconducting direct drive generators
  - Coil demonstration
  - Generator design
- Pseudo Direct Drive generator
  - Optimization
  - Demonstrations
- Cost & Efficiency
- Conclusion

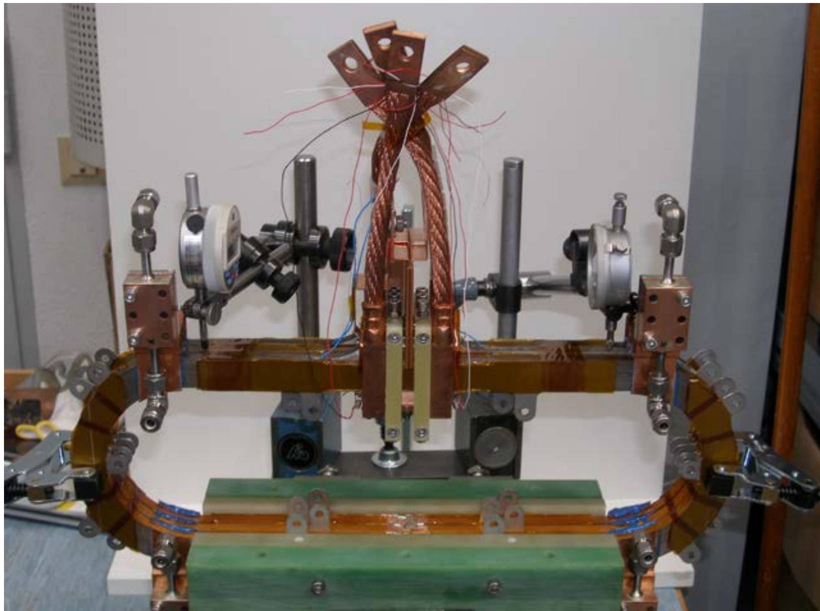


Superconducting field coil demonstrations

- SINTEF: MgB_2 wire
- 10 pancake coils stacked
- SIEMENS: High Temperature Superconductor (HTS) wire
- 8 coils, 3 stacked



- Coils demonstrated
- Some coils failed
- Full automation of coil manufacturing needed (fingers off)



INNWIND.EU D3.11, D3.12, D3.13

SC topology optimisation and comparison

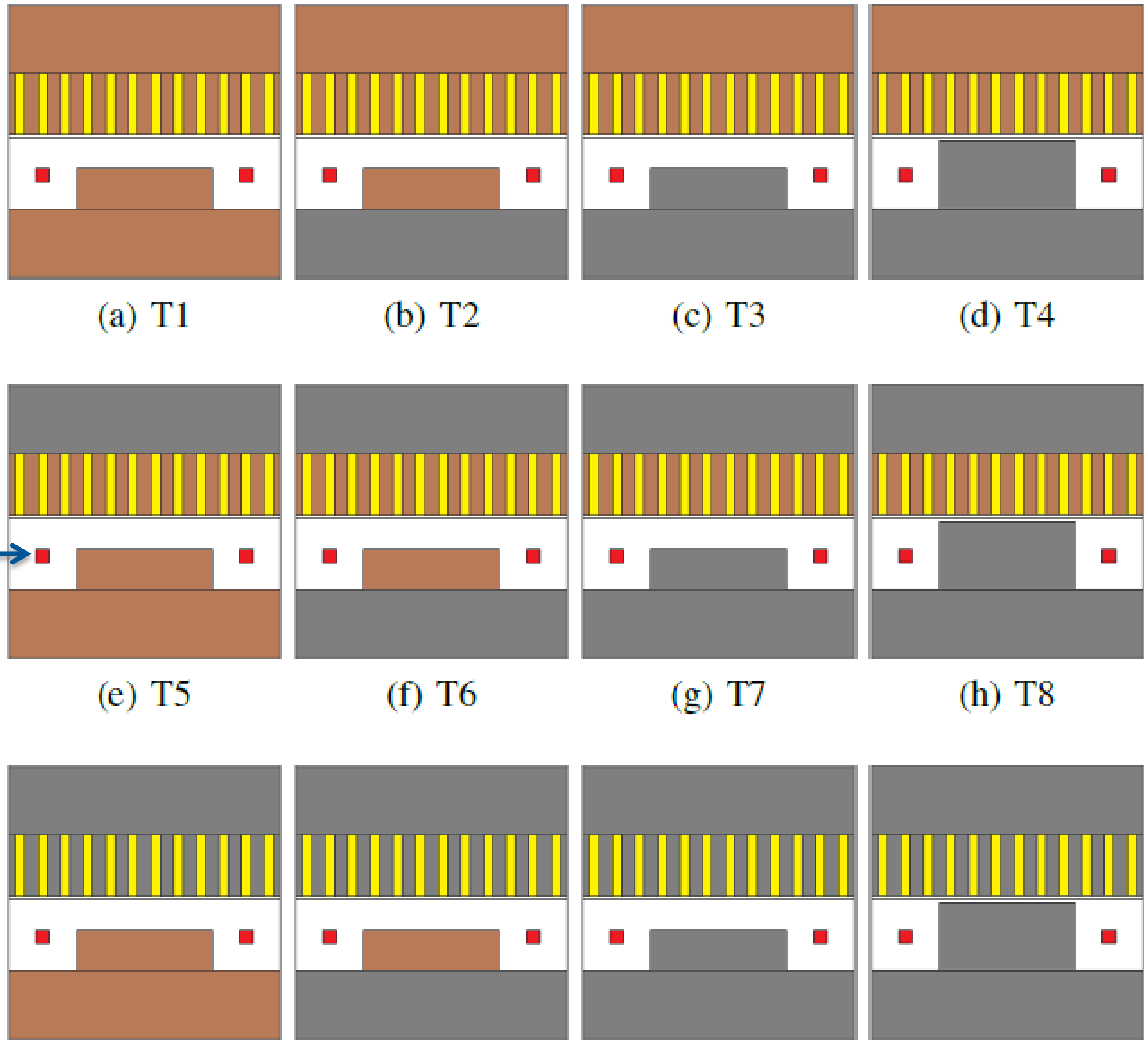
INNWIND.EU

G10
15 €/kg

Cop-Per
15 €/kg

MgB_2
4 €/m

Iron
3 €/kg



(a) T1 (b) T2 (c) T3 (d) T4

(e) T5 (f) T6 (g) T7 (h) T8

(i) T9 (j) T10 (k) T11 (l) T12

Liu et al.
IEEE TAS
2017

Optimized 10 MW

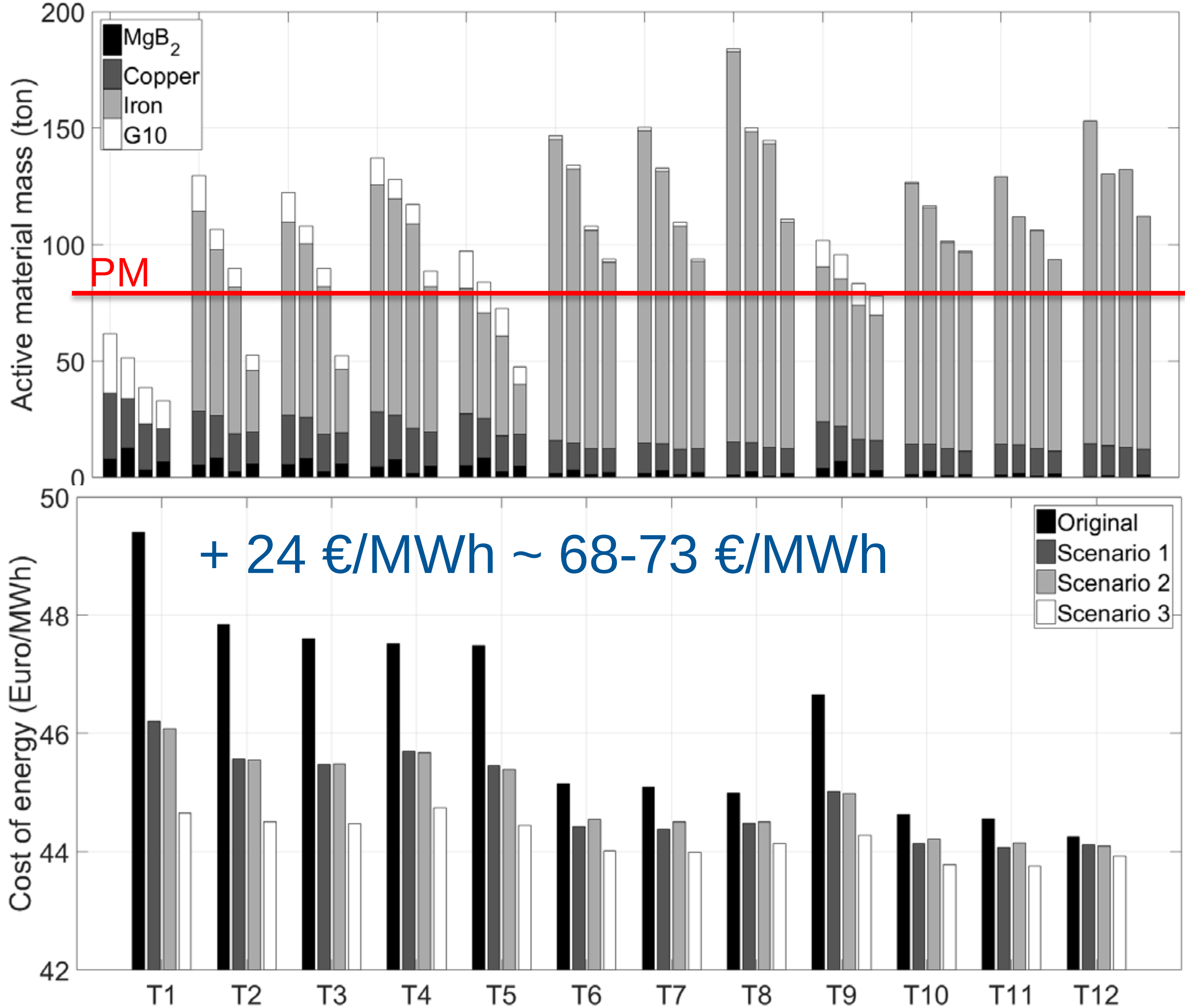
$$LCoE_{eq} = \frac{C_{act} + C_{other}}{a \cdot E_{AEP} \cdot T_{LT}}$$

- With iron:
  Cheap but heavy
- No iron:
  Light but expensive
- Future?

1: SC cost ¼

2: SC 4 x J_e

3: Both 1 & **2**

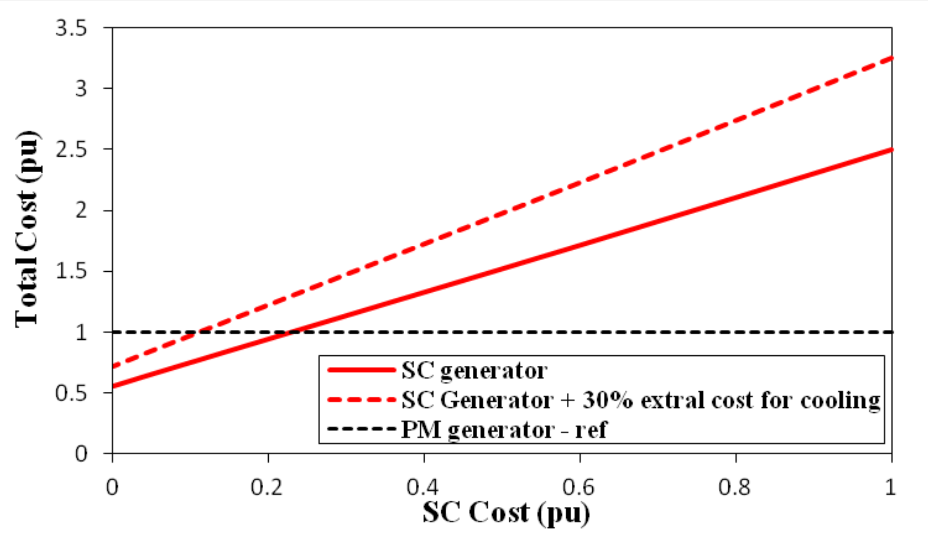


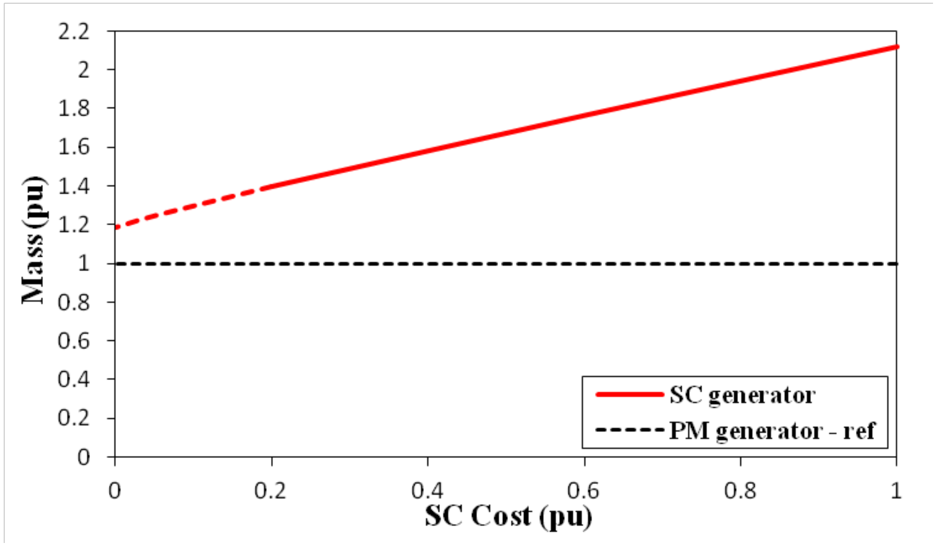
INNWIND.EU D3.11

Liu et al. IEEE TAS 2017

PM vs HTS superconducting SIEMENS

- As high operation temperature as possible → HTS SC
- To be cheaper than PM, HTS SC cost must decrease 90%
- HTS SC is not expected to be lighter than PM for iron cored topology





Concluding on SC Generators

- Models for designing and scaling SC generators developed
- Short-circuit currents limited by segmenting
- AC losses acceptable
- Low frequency power electronics no problem

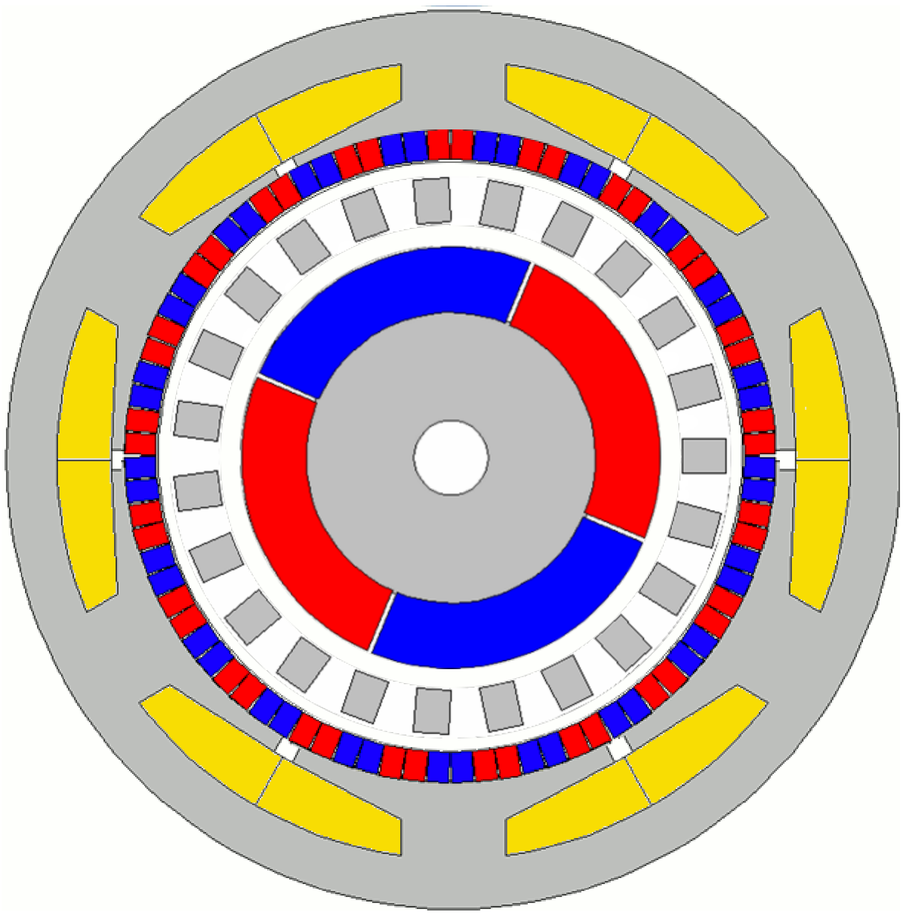
Conclusion

- Can be more compact than PMDD

Further challenges

- SC does not (yet) result in lower LCoE than PMDD
- SC coil manufacturing
- Cryogenic cooling

Magnetic Pseudo Direct Drive (PDD)

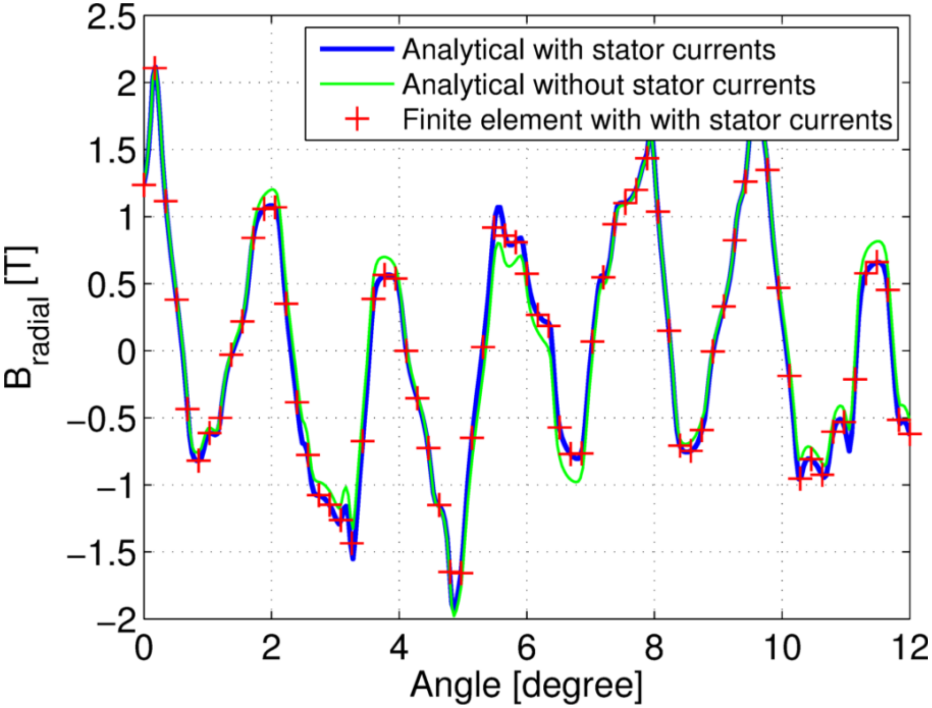


Magnetic gear
+ Generator

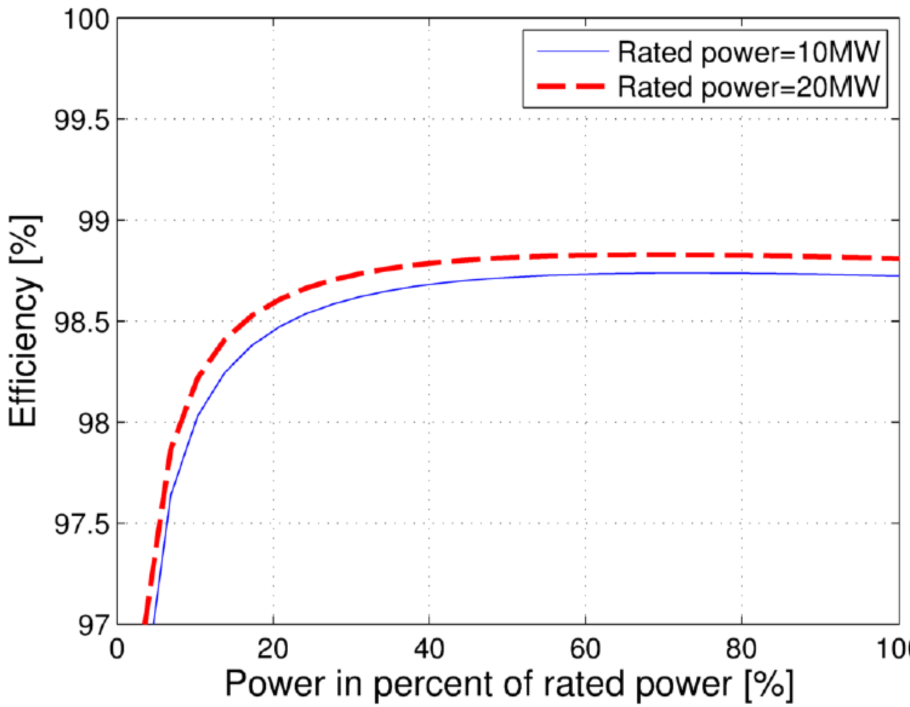
- Compact
- No contact
- High efficiency

Analytical models for design optimisation

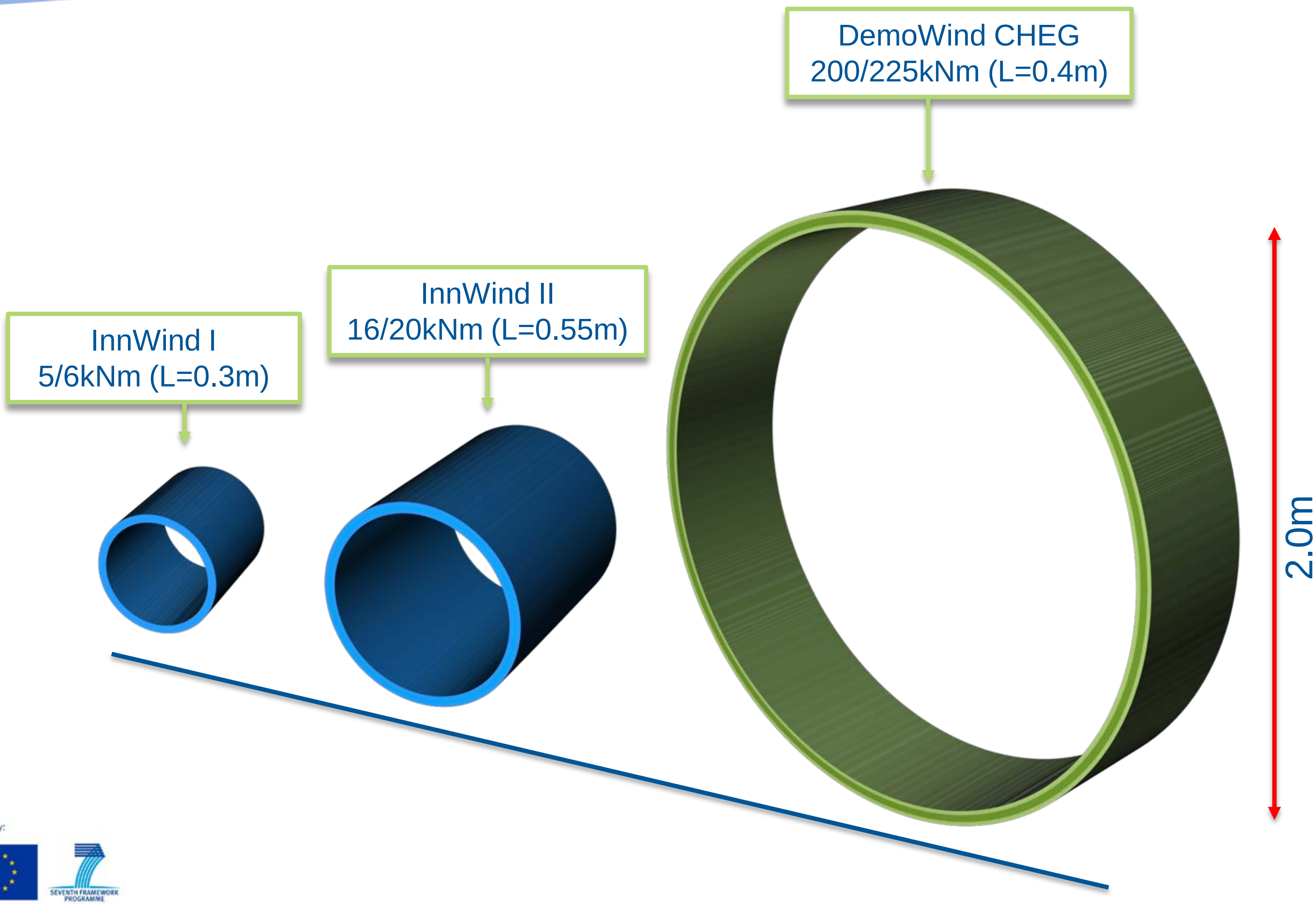
Flux density waveforms
in the outer airgap



Calculated efficiencies

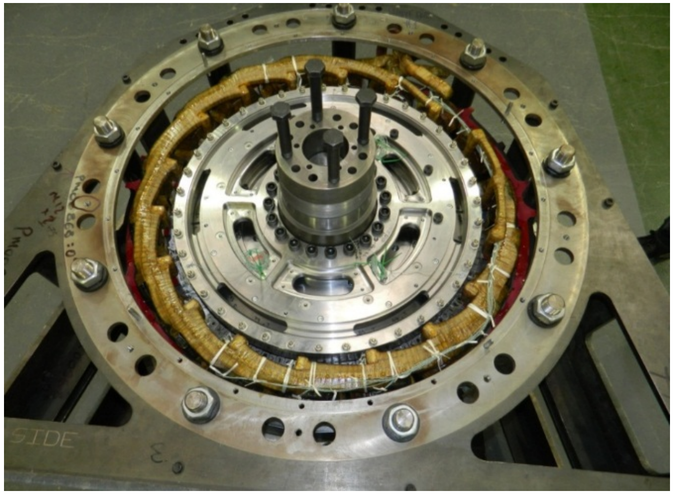


PDD Demonstrators Magnomatics

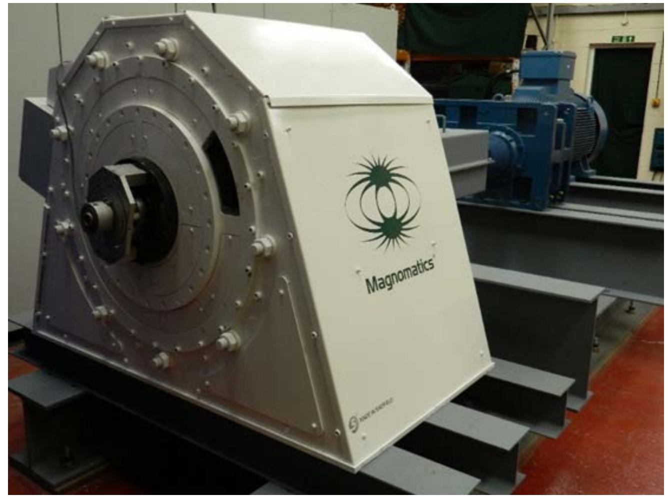


Support by:
SEVENTH FRAMEWORK PROGRAMME

16 kNm Demonstrator - New Pole Piece Rotor

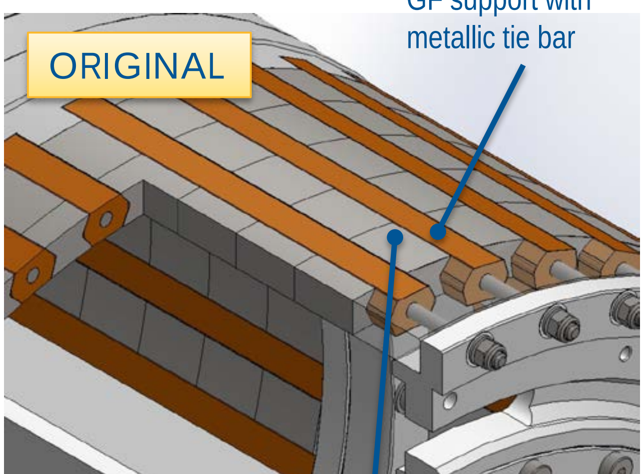


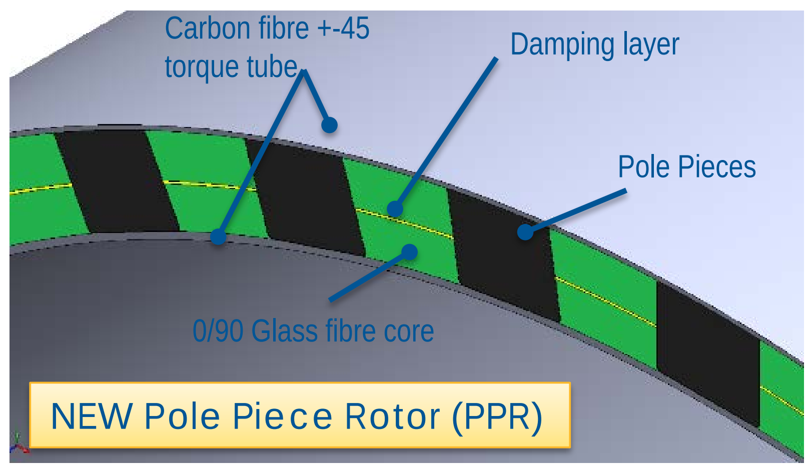
16kNm PDD during build



16kNm PDD on test

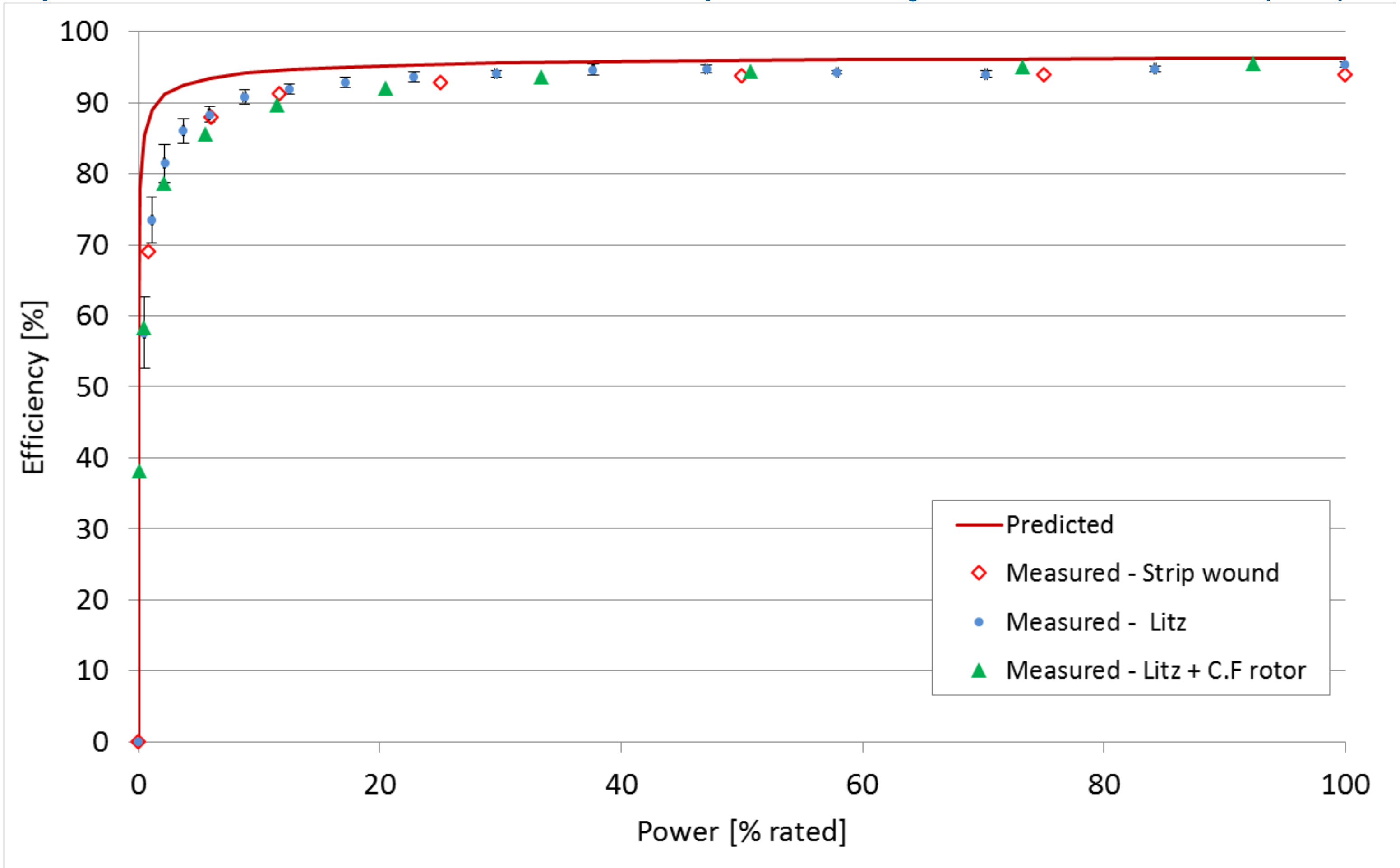
Original 16kNm PPR



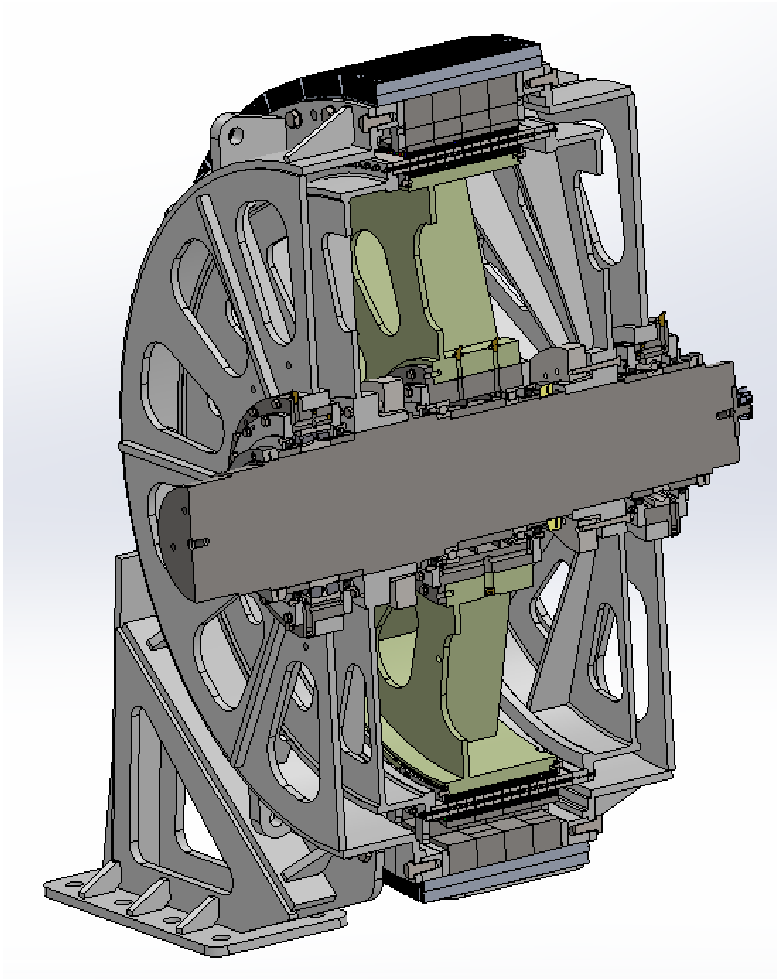


16 kNm PDD efficiency measurements

- Strip windings replaced by Litz wire
- Steel parts of Pole Piece Rotor replaced by carbon fibre (CF)



DemoWind Generator 200 kNm & 0.5 MW



Concluding on PDD generators

- Models for designing and scaling PDD developed (losses, structure, dynamics)
- Major steps in technology for pole piece rotor
- Models validated with 5 and 16 kNm demonstrators
- 200 kNm demonstrator under construction

Conclusions

- Resulting efficiency higher than PMDD
- Resulting size significantly smaller than PMDD

Further challenges

- Construction of the pole piece rotor
- Amount of Permanent Magnet (PM) material

Efficiency 10 MW