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Advanced insulation systems for wind turbine step-up transformers

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Wind turbine step up transformers – challenges

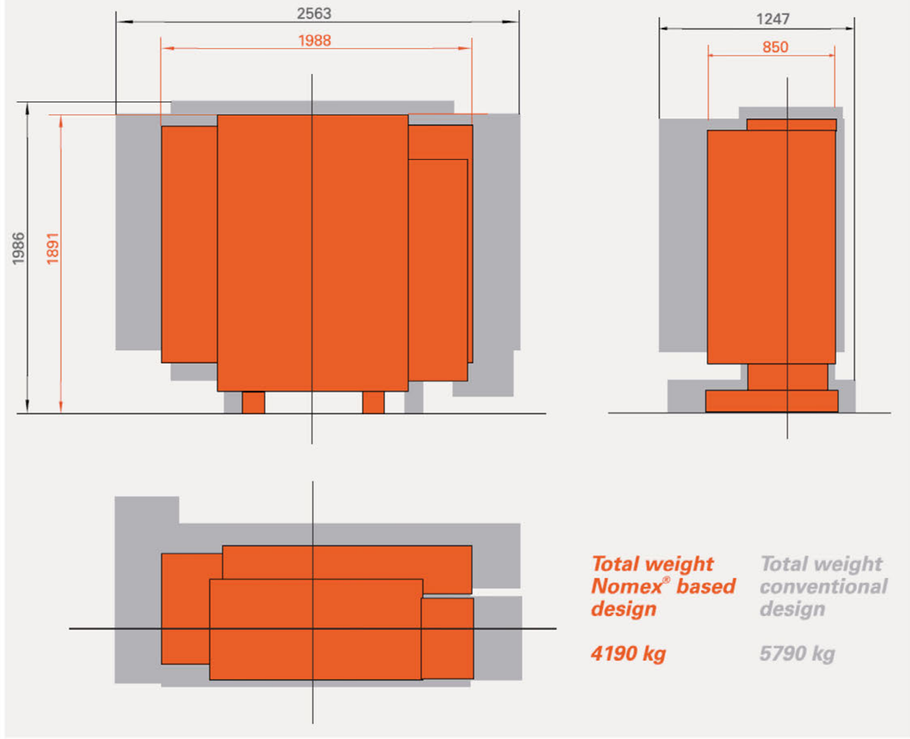
- Compact size when installed in the tower or nacelle
- Increased ambient temperature inside enclosures
- Irregular loading during day/year
- Temperature cycling
- Frequent switching due to wind conditions (inrush current)
- Voltage and current harmonics
- Step up operation
- Resistance to vibrations

Challenges in offshore installations

- Construction typical for small power transformers rather than distribution transformer
- Power ratings >10 MVA
- Rated voltage 66 kV becoming a standard (in future expected 132 kV)
- Extreme reliability required in case of offshore installations
- Almost exclusive to synthetic ester liquids

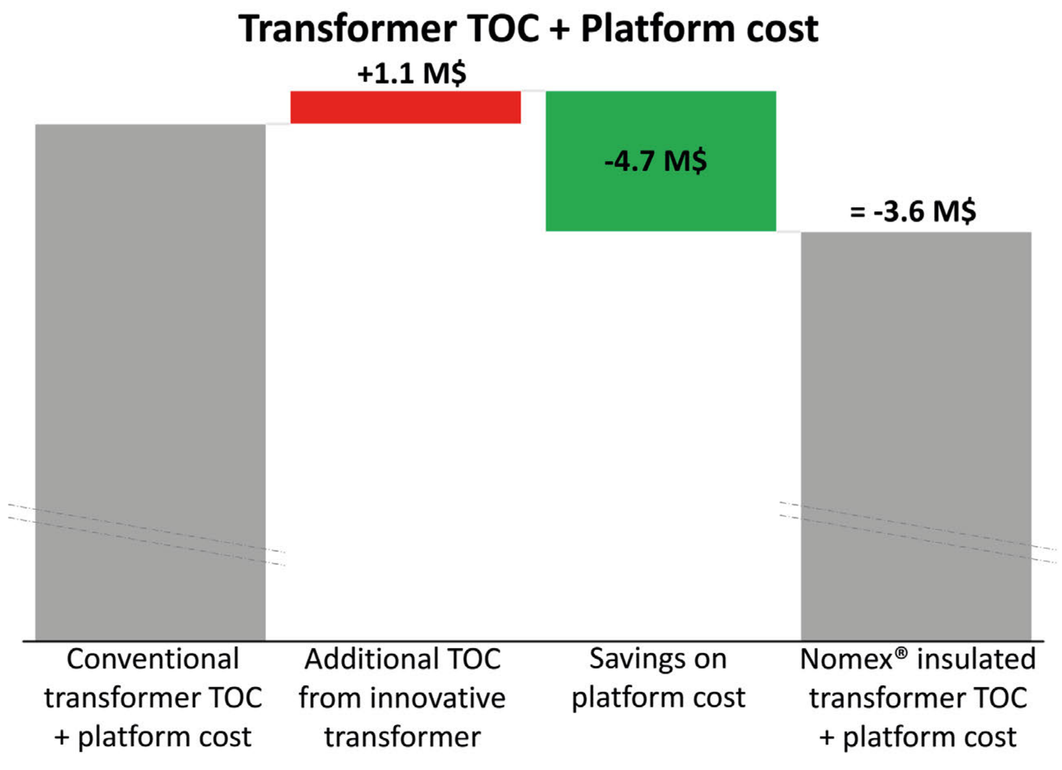
Benefits from aramid based insulation system

- Withstanding sudden variable loading/overloading
- Optimized weight/size to lower cost of mechanical structures
- Extended lifetime due to reduced insulation degradation
- Increased overall transformer reliability reducing maintenance costs



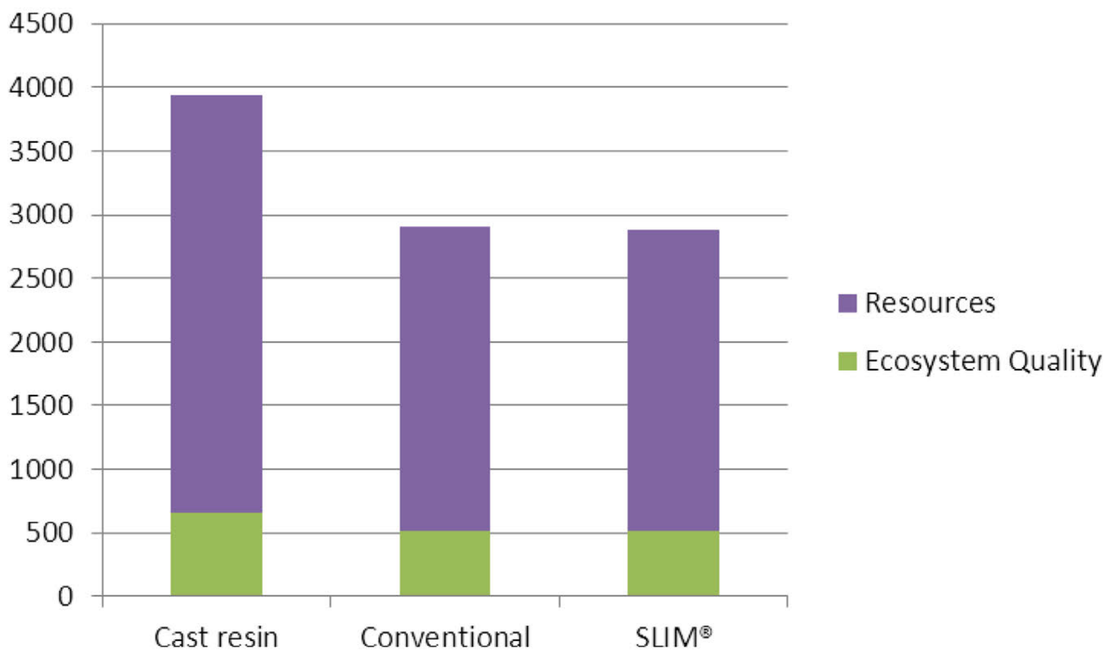
Lighter supporting structures

Advanced transformer designs with aramid insulation can make supporting structures cheaper to produce, transport and install – resulting in improved economics for offshore sites. Example cost comparison for offshore collector transformer is presented below (TOC – Total Ownership Cost). [1, 2, 3, 4]



Environmental impacts of various technologies

Results of eco-study on environmental footprint for three step-up wind turbine transformers produced in different technologies: dry-type cast resin, conventional liquid-immersed and **compact aramid insulated liquid-immersed transformer** (SLIM®). [5]



Conclusions

- **Aramid Nomex® insulation was historically used in special applications and is still the enabler in new developments of high performance transformers**
- **Advanced insulation systems can be based on high temperature aramid insulation or on aramid enhanced thermally upgraded kraft paper**
- **Alternative insulation can be used for compactness or for cost optimization, loading flexibility and life extension**
- **Various design concepts can be applied to both distribution and power transformers**

References

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2. Compact Transformers for Offshore Wind Power Plants Applications, J. Reyes et al., *International Conference on Renewable Energies and Power Quality (ICREPQ'14)*
3. Guidelines for the Design and Construction of AC Offshore Substations for Wind Power Plants, *CIGRE Brochure 483*
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5. Comparison of various technologies used for distribution transformers from an eco standpoint, R. Szewczyk et al., *CIRED 2013*

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