

# Life Extension of Wind Turbine Structures and Foundations

Tim Rubert, Pawel Niewczas, David McMillan

CDT Wind Energy Systems, Rm 3.36, Royal College Building  
University of Strathclyde, 204 George Street, Glasgow, G1 1XW

tim.rubert@strath.ac.uk

## Research Aim

Provide a technical, as well as economic analysis into fatigue damage monitoring, by application of fibre Bragg gratings embedded in wind turbine foundations.

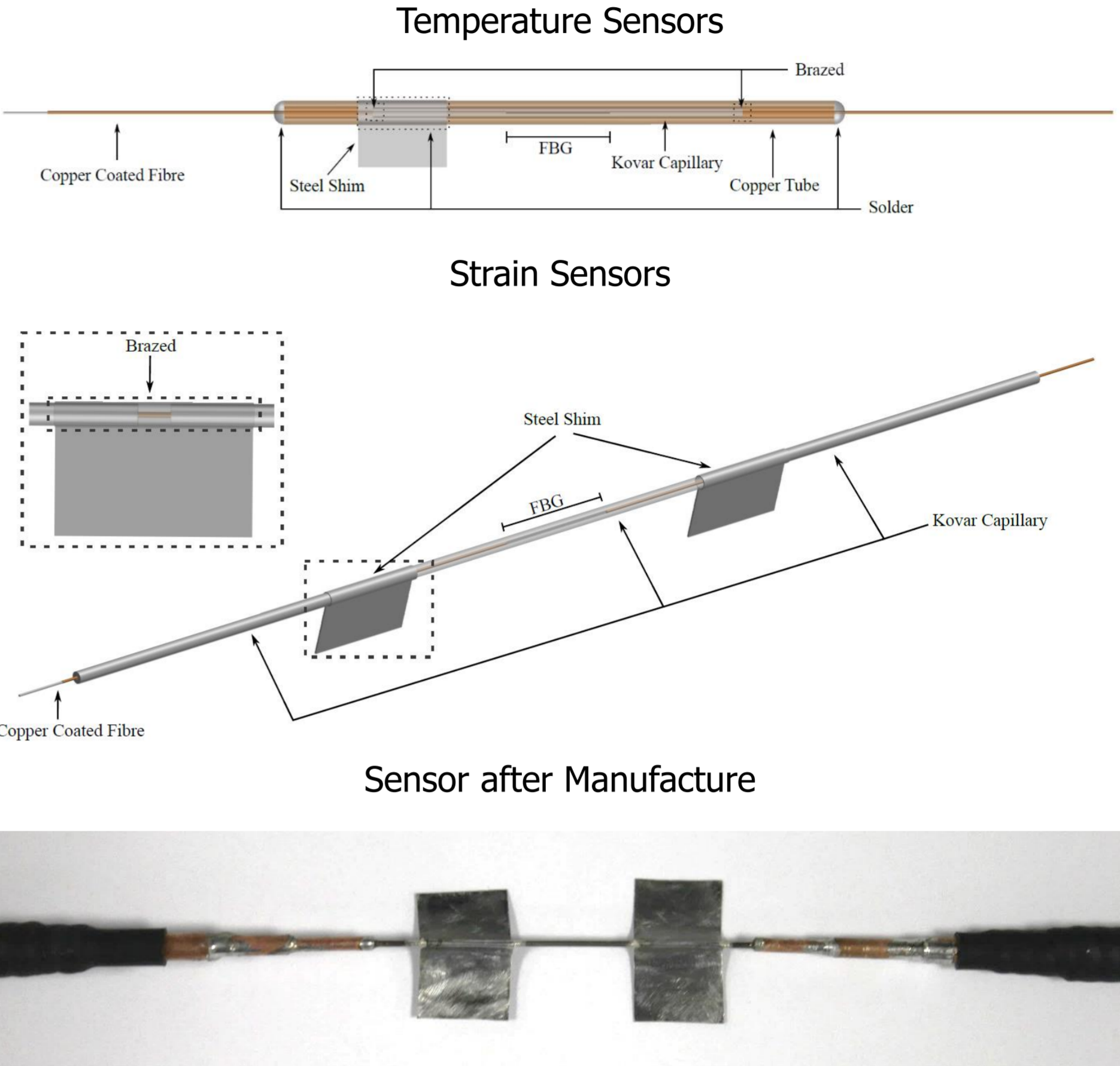
### Technical

- Evaluation of sensor fatigue behaviour
- Evaluation of sensor design
- Verification of foundation FEM modelling
- Assessment of fatigue loading
- Tipping point analysis

### Economic

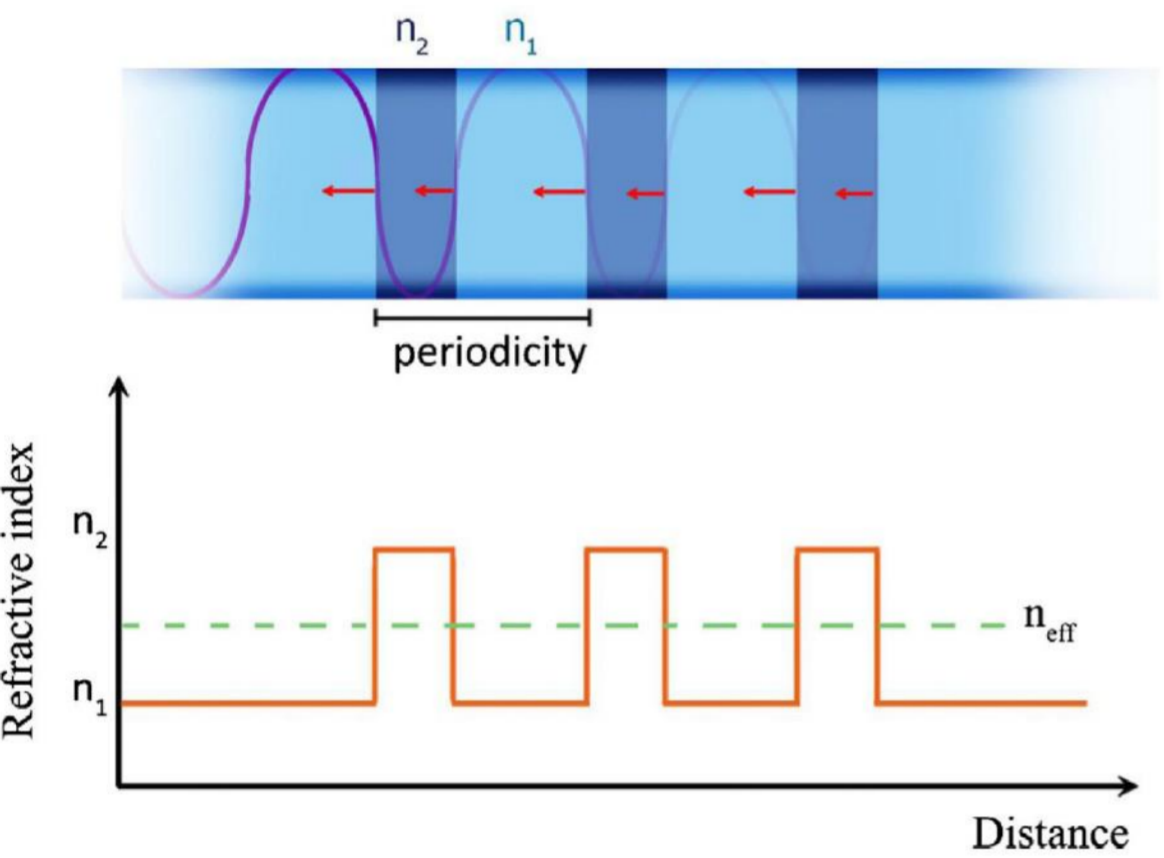
- Model wind turbine life extension
- Evaluation of economic parameters such as: LCOE, ROI, IRR under life extension scenarios

## Sensors



## Introduction

Bragg gratings measure strain and compression of optical fibres within the order of nano strain.



Along the fibre a periodic change in refractive index is engraved in the fibre, which reflects a specific wavelength according to the following Formula.

$$\lambda_B = 2n_{eff}\Lambda$$

This change in reflective wavelength can either be induced by strain or temperature as given by:

$$\Delta\lambda_B = C_\epsilon\Delta\epsilon + C_T\Delta T$$

[8]

Benefits in comparison to strain gauges, Fabry-Perot sensors, as well as SOFO displacement sensors:

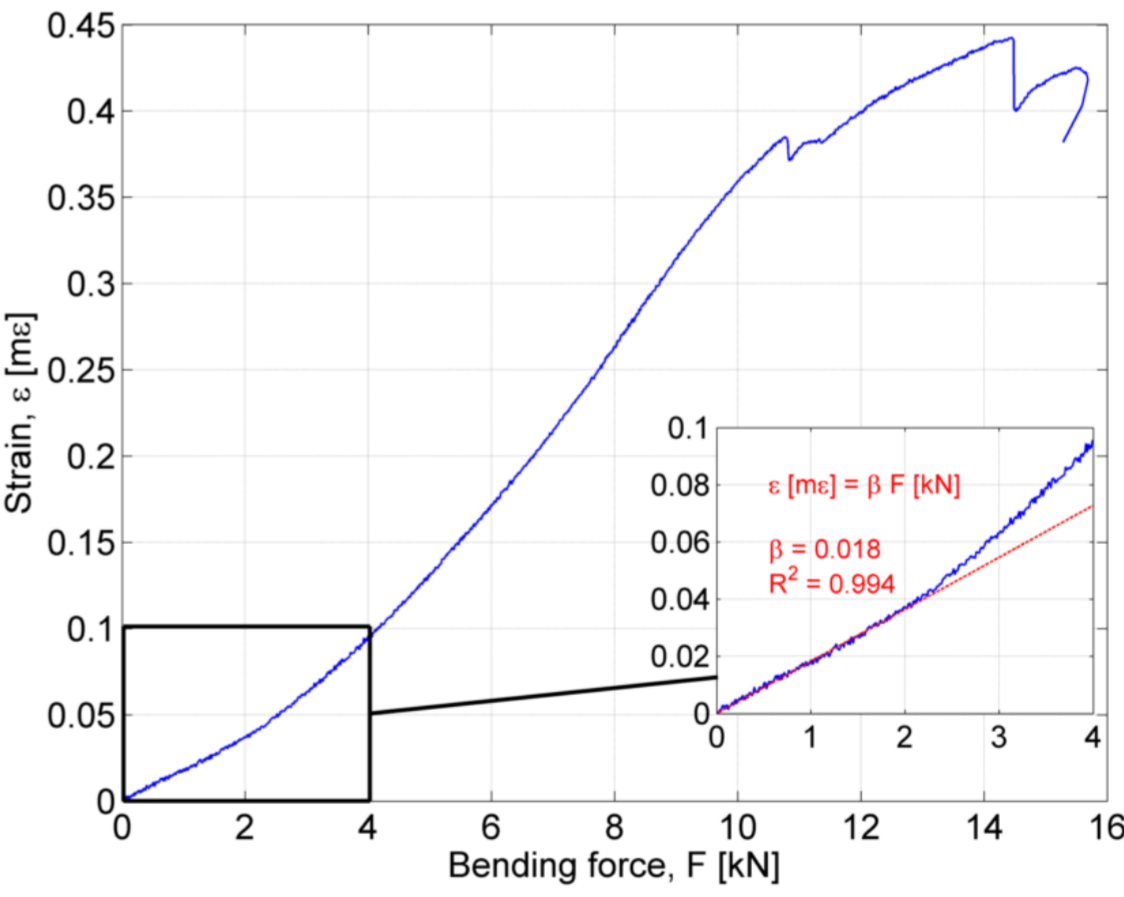
### Advantages

- Multiplexing (up to 100 FBGs [36])
- Multifunctionality (temperature, strain, pressure, etc.)
- Long transmission distance - several km [27]
- Immune to electromagnetic interference (EMI)/radio frequency interference (RFI)
- Electric isolation
- Signal integrity
- Fatigue [28,43]
- Size/weight/integration in tight areas [26]
- Linear response [59]
- Direct physical correlation between wavelength and strain [26]
- Recalibration of sensor, even after signal-processing unit has been exchanged, not necessary [26]
- Spectral shift by temperature small vs. spectral shift by strain for civil engineering application [24]

### Disadvantages

- Bleaching of sensor above 500 °C
- Costs

## Static Testing



[42]

## Sources

- [8] Y.-J. Rao, "In-fibre Bragg grating sensors," *Measurement Science Technology*, vol. 8, pp. 355–375, 1997.
- [41] P. Niewczas and G. Fusiek, "induction heated assisted optical fibre bonding and sealing technique," in *21st International Conference on Optical Fiber Sensors*, W. J. Bock, J. Albert, and X. Bao, Eds., vol. 7753, may 2011, pp. 77 536H–77 536H–4. [Online]. Available: <http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=1347129>
- [42] M. Perry, G. Fusiek, I. McKeeman, P. Niewczas, and M. Saafi, "Metal-packaged fibre Bragg grating strain sensors for surface-mounting onto spalled concrete wind turbine foundations," vol. 9634, p. 963466, 2015. [Online]. Available: <http://proceedings.spiedigitallibrary.org/proceeding.aspx?doi=10.1117/12.2190188>