

# Mac Robertson Postgraduate Travel Scholarship – report

Katarzyna Patryniak  
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## About me

I am 3rd-year PhD student at the University of Strathclyde. I come from Poland and have experience studying and working in the UK and the Netherlands. My research focuses on Multidisciplinary Design Analysis and Optimization (MDAO) of Floating Offshore Wind Turbine (FOWT) support structures, with particular interest in numerical modelling, data-driven methods, and design optimization. I graduated in Naval Architecture with High Performance Marine Vehicles and work on an industrial project focused on surrogate-based optimisation of methanol-powered ships alongside my PhD study.

In 2023 I was awarded the Mac Robertson Postgraduate Travel Scholarship of value £4000 which allowed me to spend two months as a visiting professional at the National Renewable Energy Laboratory (NREL) in Colorado, USA.

More about me and my research:



<https://www.linkedin.com/in/katarzyna-patryniak>



## Why did I apply for the Travel Scholarship?

PhD can be a very intense journey often revolving around a tightly defined research problem. However, it offers numerous opportunities to broaden one's perspective, gain insights into the broader context of the research area, and connect with like-minded individuals and fellow researchers. Earlier this year, I had a chance to present at the Wind Energy Science Conference in Glasgow, where I was lucky enough to meet a senior researcher at NREL who invited me to spend some time at their lab in the USA. Such visits are typically not paid, and the visitors are responsible for securing their funding. Fortunately, the timing aligned perfectly, as the Mac Robertson Postgraduate Travel Scholarship was open for applications at that time.

Visiting NREL in person was crucial to the research I was conducting at the time. What was the research about?

**In a nutshell:** Floating Offshore Wind Turbines (FOWT) have the potential to tap into abundant offshore wind resources in both deep and shallow waters, offering reduced installation requirements compared to bottom-fixed turbines. Many recent offshore wind projects have opted for floating substructures. However, the floating technology is not as mature yet, which leads to relatively high development risks. Mitigating these risks and costs can be achieved by improving our confidence in FOWT analysis methods. To achieve this, a fundamental understanding of the complex dynamic behaviour of FOWT systems is essential, as these structures are exposed to the harsh offshore environment and subjected to large multivariate environmental loads.

**The idea:** Intuitively, we want to reduce the motion amplitude of FOWT, to ensure smooth power output and system structural integrity. The fact the wind turbine is installed on a floating substructure that constantly moves is seen as a disadvantage. What if, instead, we could embrace the fact that it is moving in waves, and take advantage of it? Through appropriate design, can we make the FOWT rotate about a specific location where we want the motions to be minimised?

**Solution:** The kinematics and dynamics of Floating Offshore Wind Turbines are a lot more complex (and interesting!) than one might think. Through numerical simulations, it is possible to identify a point the FOWT rotates (or pitches) about, and which experiences minimum translational motion. Due to the dynamic nature of the environmental loading and the platform's response, the centre of rotation is a dynamic (or time-dependent) concept. Understanding the time history and statistics of the Instantaneous Centre of Rotation and the factors affecting it can be leveraged for better FOWT designs.

At NREL, I had a chance to work closely with renowned scientists and researchers with unparalleled expertise in FOWT dynamic response modelling and design methodologies, which helped me to realise the full potential of the above research and tackle the most challenging questions.

### Details of my visit

I had the opportunity to spend two months, in September and October 2023, at the NREL's Flatirons campus in Colorado, USA. Situated in the heart of a flat prairie terrain at the base of the Eldorado Canyon, this campus is



home to several full-scale wind turbines undergoing testing in extreme conditions commonly encountered at the site. What a perfect location to perform research on wind energy!

### Research overview

NREL is a world-renowned institution at the forefront of renewable energy research and development. By closely collaborating with the experts in the field, I hoped to learn about how state-of-the-art analysis and optimisation methods are being developed. It was an amazing opportunity for me to validate my solutions and learn about the best research practices. Last but not least, I looked forward

to being able to discuss my research on the kinematic and dynamic modelling of FOWT with the best of the best experts on a daily basis.

The research I conducted at NREL was a continuation of the previously published work titled *“Rigid body dynamic response of a floating offshore wind turbine to waves: identification of the instantaneous centre of rotation through analytical and numerical analyses”*. In that work, I have established the method to identify the centre of rotation of FOWTs. During my visit, we expanded the study by the consideration of more realistic environmental conditions and design applications of the previous findings. Together with NREL's team, we defined quite an ambitious research plan, aiming at performing a design optimisation study leveraging the new findings about the dynamics of the centre of rotation. We established the dependence of the centre of rotation on the type and severity of the wind and wave loads as well as its sensitivity to the features of the floating support structure. The research allowed us to identify the limitations of the methodology and to devise a plan for its improvement. We also gained valuable insight into how the design decisions drive the centre of rotation and the wind turbine performance.

On top of this study, I took on a side project on the development of a multi-fidelity approach to FOWT design optimisation. We came up with the idea for this project during a casual conversation with a colleague: it relies on combining my expertise in multidisciplinary optimisation with his expertise in frequency-domain dynamics

modelling. During the close collaboration on the code, we had a chance to exchange our knowledge and learn from each other. To be continued in the coming months!

### Networking

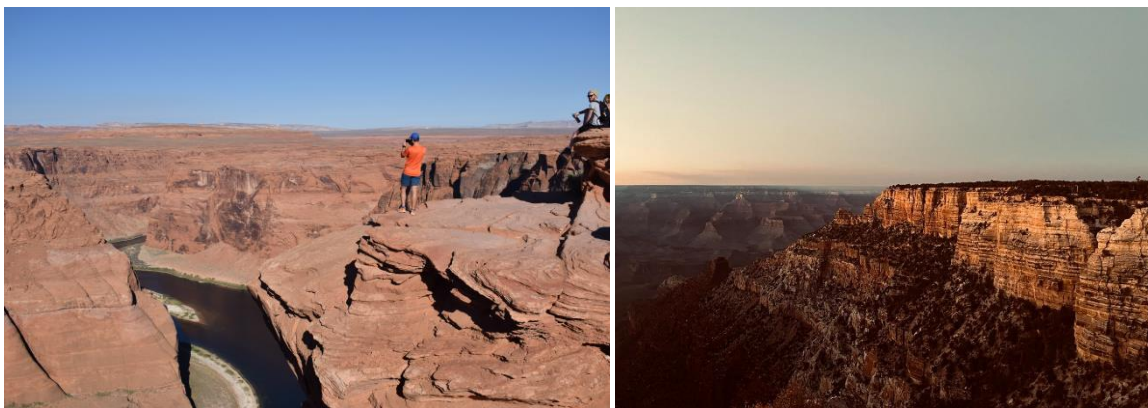
Even more valuable were the connections I made during my time at NREL - both with regular employees and with other visiting students, professionals and interns. I worked closely with a team of exceptional researchers whose work I studied before. Meeting them in person, engaging in stimulating conversations, and conducting research together was an incredible experience. The process of brainstorming, sharing ideas and challenges, and casually chatting with such a highly regarded group builds a relationship based on curiosity, openness, mutual respect, compassion and trust, difficult to develop in online meetings. Equally important were the close connections I established with other students and visiting professionals. I had the opportunity to meet people from various universities, research institutes, and companies, learning about their unique experiences and establishing new relationships. The two-month-long research visit allowed me to form deeper and hopefully lasting relationships that are worth nurturing.

### Places visited

While my time in Colorado was primarily dedicated to research, it was not all work. With the newly met people, I had the chance to immerse myself in the local culture and explore the neighbouring states. A defining feature of the local community is their love for the outdoors. Indeed, the area offers a fantastic infrastructure for activities such as hiking, climbing, cycling, rafting, and more, with spectacular views just a stone's throw away. Additionally, I had the opportunity to discover small, charming local restaurants and cafes, which provided perfect settings for further developing relationships.



I also embraced the American way of travelling by embarking on a road trip through the states of Utah, Nevada, and Arizona. We saw a sunset in the Great Canyon National Park, walked the water of “the Narrows” at the Zion National Park, engaged with the local Navajo tribe at Monument Valey, and experienced a day in a city that never sleeps – Las Vegas.





### Impact of the Travel Scholarship

During my research visit, I was able to advance the previous research significantly. The methodology and results from the earlier stages were limited in their applicability to real-world scenarios. However, my time at NREL allowed me to refine and expand them to a point where they could effectively inform a practical design process. This research, along with several “side projects” initiated during my time at NREL, will lead to an ongoing collaboration in the months following my visit. We also have plans to present our work at an international conference and publish a journal paper to share our findings with the wind energy community.

The exposure to a highly collaborative and interdisciplinary environment at NREL allowed me to see how my PhD research on Multidisciplinary Design Analysis and Optimisation can be applied in practice. I participated in casual team discussions and formal project meetings, experiencing firsthand how the diverse expertise of team members comes together to deliver tangible results. This makes an excellent context for my thesis and will undoubtedly lead to a higher impact of my work. On top of the discussions specifically about my research, I had a chance to chat about the research problems other people were facing, which significantly broadened my awareness and knowledge of other renewable energy technologies and the related challenges.

During this research visit, I had a chance to present my work to the brightest audience in the field and received valuable feedback. I also learned about their approaches to similar problems, expanding my knowledge and gaining experience with techniques and tools that were different from what I was accustomed to. I cannot emphasise enough how important it was for my personal and professional development to step out of my comfort zone and be open to alternative approaches. I was fortunate to experience a remarkable organizational culture at NREL: I became a part of a working environment filled with open-minded people who prioritise relationships, choose collaboration over individual work, and support each other to do their best.

Without a doubt, my visit at NREL was the most enriching experience throughout my entire PhD journey, and a life-changing experience. I could not be more grateful for the opportunity I was given. Warmest thanks to the donors of the scholarship for making this happen.