**Seamus Flannery**

**Lab Notebook Document**

**Master’s Thesis, 2024**

**MSc Sustainable Energy Systems**

**University of Edinburgh**

**3/6/2024 ------ ------ ------**

First in-person meeting with Velosco

Brief presentation by Kutlu on Velosco, services, models, areas of research

ABEX defined (cost of decommissioning/abandonment)

Python Alogrithms/SaaS, user web interfaces

Excel and VBA macro algorithms for wind farm cable laying distances/capex

4 Proposed research areas for me in Kutlu’s Slides

Choosing a topic for me:

Narrowed down to floating turbines, better Velosco models and in vogue for industry

Can use pyWake for tools involving turbine wakes – I should read up on this

Eliminated OpEx as research interest

Discussed crazy ideas of bi-stable flexible farm design for bifurcated wind trends

Shared moorings, model as a bi-stable ~~origami surface~~ crystal lattice of mooring weight forces, which reacts to wind speed – could have variable buoyancy mooring weight to control turbine spacing for optimum. Learn more about stationholding procedures, slack limits, etc

Assigned for next meeting: Come up with 3-4 Bullet point thesis questions for wake loss on floating turbines, dealing with capex, EYA, farm topologies

Discussed first steps for Velosco Partnership, (after NDA) when I get a computer from them I should start by trying to replicate some of their current python scripts from a windows environment to my mac and still have them run. Check that pywake is updated and their scripts still work with updated pywake

Sign NDA once it’s sent to me. (Later note, followed up with Andrew Aveyard 3/12/24, still waiting as of 3/17/24)

**3/13/24 ------ ------ ------**

Created powerpoint presentation with my research question ideas:

* Ambitious: Full Passive Dynamic Config. Farm
  + Subtopics: mooring system, stationholding control, eya/capex
* Stationholding effects on Wake
  + Different Radii Wake Effects
  + Distribution of turbines under different wind/wake conditions
  + Methods for novel stationholding moorings (CapEx)
* Investigation of Shared mooring systems

Unfinished as of 3/17/24 – I have lots of upcoming assignments!

**3/29/24 ------ ------ ------**

**Meeting with Velosco:**

Research Question Narrowing: Investigate the wake loss dependencies on station holding, can relaxing the bounds of station holding decrease wake losses? Is this financially/technically feasible?

Setting up recurring virtual check-in weekly Wednesday at 9:00

Monday 22nd 11 am meeting at Edinburgh office – hopefully NDA back by then so we can review the models that day

Scott Rosie the apollo quick disconnect mooring person – hope to set up a meeting

“Plug and play” – removes a lot of maintenance down-time – can this be used to actively control stationholding constraints?

Scott will be able to help us learn more about stationholding and how strict it is and why

**4/22/24 ----- ----- ------**

**Meeting with Velosco:**

* + Goal: see models and refine thesis mission statement
    - Refined title from “Hypermobile offshore floating wind farms to “Dynamic Positioning in Offshore Floating Wind Farms”
    - Refined scope of Project
    - Planned mission statement details
    - Clarified capabilities of models

**4/24/24 --- --- ---**

Mission statement written and sent to Andrew

4/25/24

Mission Statement approved by Andrew and submitted

4/29/24

Morning meeting with Velosco, reviewed code base, received modelling files from Scott on Teams.

Thought I’d already successfully installed PyWake (py\_wake), but I’d actually installed Pywake (pywake, somebody’s homemade solution to activate python scripts over a LAN activation command or something).

Afternoon, attempted to set up real PyWake (py\_wake) installation, unsuccessful due to issues with Conda setup

Created Private Github Repository - <https://github.com/SeamusFlannery/Dissertation> (Private, need people to be added in order for them to see it).

4/30/24

Conda instance still heavily bugged. Resorted to Stack Overflow for help, no answers. New question posted no answers. Circumventing Conda for pip installation not working.

5/1/24

Reinstalled pip via homebrew and magically py\_wake was able to be installed! Set up new conda environment in PyCharm which included py\_wake, and set up quick start tutorials to learn py\_wake.

5/2/24-5/3/24

Continued learning py\_wake (hereafter discussed as pywake or PyWake, despite earlier python package name ambiguity) and the Velosco data pipeline

5/6/24-5/7/24

Struggling with aep function and modifying for different wind-roses

Figured out set normalize\_probabilities=True in aep to keep it from ignoring the direction frequency parameters I set in the site object. Can use this to make comparative simulation?

Meeting with Andrew (5/8/24)

Wind Power Lib (easy to use farm package) [https://windpowerlib.readthedocs.io/en/stable/#](https://windpowerlib.readthedocs.io/en/stable/)

Second tool -

<https://atlite.readthedocs.io/en/latest/index.html>

Atlite: Convert weather data to energy systems data — atlite 0.2.13.dev28+gc1e29e8 documentation

**Meeting with Scott Love and Nigel (Apollo) @ All-Energy Conference May 15 2024:**

Discussed possibility of Apollo Collaboration, potential future meetings, costing and figures advice

Discussed complimentary systems to mobile turbines which are not mooring (systems to move turbines) including sails, magnus effect sails, and wake-steering thrust. Could be interesting to include a section on these systems in the dissertation.

**Meeting with Scott Love @ CodeBase May 17 2024:**

Discussed scenarios we want to model

* bifurcated or trifurcated? Modes of breathing? Wind data types?) See phone picture of whiteboard for details.
* Ran early antagonistic model for 24% loss AEP at Hornsrev with forced bifurcated wind in the wrong directions.
* Discussed goals for literature review, which should cover technologies (speculative and existing) which could accommodate this motion. Literature review should include costing models
  + Need to make wish list and project explanation to send to Nigel (Apollo)

May 17 2024 Flo Wave Event

* EnerOcean two turbine model repositions the base in order to orient the turbines as they have no nacelle yaw control (investigate their mooring systems!!)

June 7th – I have forgotten to update this book since May,

Since then, I’ve significantly updated my modelling, and I’m currently working on getting time series modelling of my farm to work. Initial testing on bifurcated wind on V80 turbines showed there could be up to +14% energy yield difference from allowing turbines to slide out of oncoming wakes, perpendicular to the wind direction. Random placement testing yielded significant loss and impossible farm designs – moving away from concepts of passive motion. Today I read Cao, Ge, Et al 2022 on multi-objective wind farm layout optimization – they say single-objective is no longer enough 🡪 good additional motivation for investigating mobile layouts. Implemented the NREL 15MW turbine into my code. Made a free account for limited access to data from a company called Vortex, which I hope to be able to use as time series data. May also need to generate sample data for different test scenarios.

<https://arxiv.org/pdf/2401.08484> depicts a study similar to mine (also a master’s thesis? co-authored by faculty), but at a much smaller scale and interested in control strategies more so than opportunity and technological supports.

**Meeting With Veosco 10/6/2024**

Checked in about current progress,

Defined 18-27 Scenarios to plug into my models and the cap ex model:

1. Two farms: 2X3 and 5X5 (optional to include 10X10 if we have time)
2. Three wind scenarios
3. Three mooring depths

Re-established todo list:

1. Build vortex data pipeline (first vortex data delivery today, requesting horns rev data which will have a lead-time, most likely)
2. Get at least Weibull AEP bonus estimates for each scenario (depth not counted)
3. Run time series on each scenario using vortex site data for relevant wind roses

**Updates as of 19/6/2024**

Attended multi-rotor conference last week – wake benefits/adaptations of multirotor show that there is increasing desire in the field for creative wake solutions. Also reinforces the need for exploration of platform design – multirotor can only yaw easily while floating or with hanging spaceframes, so it makes floating offshore an attractive location for multi-rotor.

Did some light reading on wake effects during curtailment and on the vestas wake steering system.

Finished writing my time-series protocols in python, except that I found that the PyWake simulation for time-series wasn’t behaving as I expected it to? Which is a major problem that I need to find a work-around to.

Meeting in Faraday building with the Lyden Group – mostly unrelated work discussed, received some good questions, Lavin offered to help contact the PyWake dev team.

**Updates as of 10/7/2024**

Time series modelling accomplished – preliminary results compiled

**Progress presentation given presenting those preliminary results**

Need to verify PyWake behavior

Need to quantify uncertainty – plan to perturb current dynamic/time-series models

Beginning to write methodology section for pyWake

Sample turbine coordinates sent to Yakup @ Velosco to begin collaborating on CapEx model

**Updates as of 3/8/2024**

**Its been a while but I’ve been busy – here’s the goings-on summarized**

* Finalized yield results and verified everything about PyWake. Behavior is as intended.
* Yield uncertainty tested with Vortex validation statistics.
* Monetary estimations of NPV and Payback period from the yield numbers
* Yesterday met with Will Brindley at Apollo engineering to discuss the engineering constraints on the moorings and IAC for a dynamically repositioned farm. Really wish that this would have happened earlier – pretty much all of our CapEx work relied on Velosco’s model for mooring costs, which is built around chain moorings. Will clarified that this project would almost certainly not be using chain, almost certainly would use polyester line for mooring instead, with maybe small sections of chain or nylon. This would behave entirely differently in the water column and has a totally different cost basis. Will also helped quantify winching requirements and track down cost info for winches.
* Working on re-doing CapEx from base assumptions for polyester mooring. Hoping Velosco can still help with IAC cable costs. Frustratingly their excel models won’t work on my laptop, and I really struggle to interface with their shared Microsoft tools/environment. Hoping I can get their tools to work on a library Microsoft computer, because otherwise I’ll need Scott to run it in the office with me again, and I think he’s not very interested in doing so, or perhaps a little annoyed with me/the Microsoft situation. I have created my own bottom-up estimation process for IAC costs, but It’s much more rudimentary than the Velosco models so ideally wouldn’t be the be-all end all
* Writing up the dissertation. Was supposed to meet with Andrew yesterday to discuss structure but he had to cancel an account of a veterinary emergency. Hopefully we can reschedule for early next week as I’d prefer not to have to retroactively restructure my writing. I’m particularly struggling with where to draw the line between introduction/motivation and literature review. I plan to have both as there’s a lot to discuss in technological background and wake structure that also don’t belong in a motivation section. I think the motivation section is pretty easy to structure/make cohesive but I’m not really sure how to structure the literature review section either.
* Finished my poster, but going to review it in a few days when I have a better understanding of the cost component and my conclusions, and also to give myself time to look at it with fresh eyes. Its tough because what people want out of posters is always very different. Tom Bruce (very very text heavy, and zero whitespace) had a definite style of poster he wanted which was very different to what I was taught in undergrad. Maybe I’ll ask Andrew. Stylistically, I always prefer to know my material and present the poster information from my head rather than having all the information written explicitly on the poster, but I don’t want to loose marks for not having an informative poster that can operate at the same level without me presenting it.

**Updates as of 16/8/24**

**More or less finished writing the thesis**

Still working on finished touches and incorporating Andrews suggestions on my methodologies chapter (which he’s had a chance to review) across to my other chapters. Today in particular I redid a lot of my plots which was a little code intensive for some of them, but they look much more professional now. I also worked to replace some figures which had been screenshots of excel tables with LaTeX tables, but that proved to be an absolute LaTeX nightmare, and I lost a lot of organizational and color-coded information in the process so I decided to go back to the excel tables, which give me a lot more influence over table design. My poster presentation went well, I didn’t really get to talk to that many people to be honest. I did appreciate a conversation with Brian Sellar who was interested in how my topic related to tidal turbines, axial induction control, and wake steering there, but also asked a lot of interesting questions which have informed my editing process on the thesis. Last task from today was writing up a list of to do’s before submission that I will handle tonight or tomorrow. Deadline is Monday the 19th, so I have tonight, tomorrow, Sunday, and then the morning of Monday, if need be.

**Updates as of 17/8/24**

**Finishing touches**

I have commented my code, done a second revision read through of my thesis, and added all of my linked content to my appendix.

References checked

Figured out I could classify images as tables without actually creating a latex table, which allows me to at least trigger the \listoftables part of the frontmatter, so I did that to all my table (inserted screenshots from excel, and redid the cross references and labels.

**Updates as of 18/8/24**

**Actual Finishing touches**

1:10 pm officially finished edits.

1:23 generated title page, exported my mission statement file as a PDF, and added both behind the cover page of the LaTeX output PDF, as per the handbook instructions (there was no place for these additions in the LaTeX template). I think that’ll be everything. Adding the file to my Github repository, doing a last commit. Then I’ll turn in the thesis when I’ve called my mom and grandmother to show them haha.