

Risk Assessment and Project Management

Nathan Skyrme

Introduction

In order to transition away from the traditional energy source of fossil fuels, renewables need to be in apt enough supply to allow continual consumption. To achieve this construction and development will need to shift to a focus on renewable energy generators. The following is an environmental risk report for the installation of a 2MW wind turbine, to determine whether construction is viable on a site which is on a remote Moorside location, adjacent to a stream, a Site of Special Scientific Interest and a working farm.

Findings

RISK ASSESSMENT TITLE										
Moorside SSI Ecological Survey										
RISK ASSESSOR NAME					BRIEF DESCRIPTION OF ACTIVITY			DATE VALID FROM		
Nathan Skyrme					Assessment of the viability for construction on a Moorside SSI adjacent to a stream			19/11/2022		
AUTHORISING LINE MANAGER					DATE(S) / LOCATION(S) OF ACTIVITY			REVIEW DATE		
Dr. Michael Goodfellow-Smith					ONGOING / Moorside SSI			19/11/2023		
HAZARD	POTENTIAL HARM	RISK RATING			CONTROLS			RESIDUAL RISK		
		See Risk Ratings Tab						See Risk Ratings Tab		
		List what could cause harm from this activity.	For each hazard, identify the type of harm that could occur eg biological, physical, chemical, safety, ergonomic or psychosocial	Severity	Likelihood	Risk	For each hazard, list the the measures you will be taking to minimise the risk identified.	Severity	Likelihood	Risk
Undiscovered Bog	Sinking, not viable for construction	5	4	20	Boreholes, pit and trenching.			3	2	6
Overflow Moor Flooding	Flooding of turbine site, damage to turbine, soil integrity degraded	3	5	15	Diversion, water pump extraction.			2	5	10
Moist/Soft Ground	Turbine sink/collapse, not viable for construction	3	3	9	Boreholes and trenching, monitoring of ground near moor.			3	2	6

Wildlife/Ecosystem Disturbance/Destruction	Removal of key ecosystem component, contributor to or erasure of species, fines	2	3	6	Species monitoring (up to 2 years), regulator inspection, list of species present, site segregation, net biodiversity gain.	1	2	2
Sphagnum Moss (Peat Bog)	Degradation of turbines concrete base	5	4	20	Removal and monitoring of peat bog and sphagnum moss.	4	4	16
Removal of Sphagnum Moss	Removal of plant that absorbs carbon and prevents flooding	5	5	25	Leave the Sphagnum Moss and Peat Bog as they are, decide site is not viable for construction.	1	1	1
Unexpected Underlying Geology	Site rendered not viable for construction	5	3	15	Boreholes and Geological Maps. Trenching (if appropriate).	2	1	2
Stream Overflow Flooding	Flooding of turbine site, damage to turbine, soil integrity degraded	3	5	15	Diversion, water pump extraction.	2	5	10
Overflow Run-off	Silt being distributed into the stream/moor, natural resources wales fines, harms/destroys wildlife	3	3	9	Use of water pump instead of diversion (more expensive).	1	1	1

Moorland Wildlife	Death and possible eradication of birds in the area	4	5	20	Either determine site not viable or relocate. (Relocation expensive and complicated, may not be allowed.)	3	3	9
Natural Resources Wales	Not granting a construction permit due to disturbance of wildlife and ecosystem.	5	4	20	No control measure available. Construction will not go ahead.	5	5	25
Noise/Vibration Pollution	Disturbance to wildlife, public and the working farm.	3	4	12	Tuned dampers, placing the turbing 500-meters from the farmhouse (recommended by Welsh Government.)	3	3	9
Aesthetic Devalue	Ruination of natural aesthetic, poor public perception of renewable energy and the project	2	3	6	Immersion/covering of the turbine so much as possible	2	2	4
Road Excavations	Removal of and degradation to biodiversity	2	3	6	Compliance with BNG to replace with 10% gain, survey to determine plants in area, redistribution of integral plants	2	2	4
Road Infill Material	Aesthetic devaluation, introduction of foreign material, repeat maintenance needed	1	2	2	Assess possibility of using excess excavated soil to create a dirt road, determine material least damaging to surrounding area	1	2	2
Excavation and Soil Moving Equipment	Sinking, track impressions across the moor, soil spillage	1	2	2	Complete geological survey before equipment arrives, fill in, smooth and regrass any tracks left by heavy-duty equipment/transport, recollect any fallen soil	1	1	1
Fuel Storage	Aesthetic devaluation, increased land-use, turbine must off-set emissions from battery production, battery disposal	3	3	9	Assess emissions off-set before project undertaken, battery recycling	2	2	4
Oil Storage	Yearly replacement, turbine must off-set use of PAO, cracking and seal breaking causing oil leaks, pollution of water (harm to environment, humans and livestock)	4	3	12	Regular assessment (remote and manual), immediate maintenance completion, assess emissions off-set before project undertaken, construct so far away from any watercourse as possible	4	2	8

Analysis

Analysis of key concerns noted in the risk assessment

Undiscovered Underlying Geology

Underlying bog is one of the key ecological factors that could prevent the entire project from being undertaken. If there is found to be underground bog across the moor (which is highly likely), this will prevent the project from being able to go ahead. If construction were to go ahead without check this would likely lead to the turbine sinking, whether immediate or in the future, due to its gargantuan estimated weight of 295-Tonnes (Crossley, 2014, p. 5) being constructed upon soft and malleable ground. Before beginning an initial check with a borehole could be performed, and if looking promising a trench excavation can subsequently follow. However, if bog is found, it may be too deep or just impossible to safely or fully remove. Even if none is present, there is no guarantee that excess water from the moor won't seep into the ground under the turbine and damage its integrity. The bog will require active monitoring to ensure this doesn't happen, both at the turbine and along the length and surrounding area of the underground cables. There is also a real risk of sinkholes on the moor, in order to ensure that underground caves are not present, and that construction is completed at bedrock level, geological maps would need to be carefully examined. Sinkhole risk is elevated on mined or limestone moors, making an initial check of the moors expected underlying geology imperative.

Moor Overflow Flooding

Flooding should be expected on a UK site as heavy rain fall often occurs. This usually would not pose any real issue, but due to being on a moor the situation presents itself as one. Much moorland is generally synonymous with bog when wet (Britannica, 2022) so it would be fair to generally expect this to reflect the ground condition of the site, especially during the autumn and winter months. If wetland moor were to flood and spill over it would both damage the integrity of the ground underneath the turbine and potentially prevent access to the turbine itself. If the likely flooding often seen on moorland in the UK occurred, the turbine site could become akin to a swamp. Depending on the amount of flooding it may be reasonable to attempt to divert the excess water to the adjacent stream. However, the contents of the water would need to be closely examined and tested due to tight regulations from Natural Resources Wales on overflow run-off that bestows owners of land that contains a watercourse with strict responsibilities (Natural Resources Wales, 2022). Previously construction companies have received fines of around £32,000 for allowing 'suspended solids' such as silt to run-off through a natural watercourse (Natural Resources Wales, 2020). Pollution of the stream from allowing solids to enter will harm wildlife and damage the purity of the streams water. To avoid fines the most feasible action to take in case of flooding will be to dewater the site with an industrial water pump, to do this a permit from Natural Resources Wales will be required, which can with foresight be obtained before construction begins. A small-scale dewatering system costs approximately £5000 plus incurred expenses (Checkatrade, 2022) from construction not being able to go ahead whilst extraction takes place. Consecutive flooding would then only

incur the cost of the site having to be temporarily closed since the pump has already been purchased. As a result of elevated flood risk, whilst constructing the transformer for grid connection it would be more suitable to place it at an elevated height away from any bog or watercourse so far as reasonable. There is potential for a fire from the transformer in case of flooding and post-flood it would need to be shut down and dried, causing further hassle and cost (Sivaraja, 2021).

Wildlife/Ecosystem Disturbance and Destruction

In order to avoid disturbance to or destruction of species and plants integral to the moor's ecosystem an intensive survey and analysis of the site should be conducted prior to construction, as well as correspondence with and recommendation from Natural Resources Wales as to the specifics of why the site is classified as of special scientific interest. Depending on the reasoning it may be that the site is not viable for construction due to the effects of construction taking place, which may contribute to or remove/damage a key component of the moor's ecosystem. If this were to happen, particularly after recommendation from Natural Resources Wales, fines would be issued, and the project may get shut down completely. Analysis of the site to monitor the wildlife species present should be conducted for up to 2 years and can be undertaken through a third party such as Moors for the Future. If after monitoring the site is considered viable it will become the construction company's responsibility to relocate and segregate wildlife to ensure it does not enter the site again, relocation will need to be of a distance at least 675-metres from the turbine to minimise death (British Ecological Society, 2019) due to increased eradication by way of collision with turbine blades as a result of lost habitat. Species monitoring will need to optimally be continual to prevent birds migrating and nesting closer to the site gradually over time. In line with Welsh planning policy Biodiversity Net Gain (BNG) will need to be adhered to, the site will need to compensate for degradation to the surrounding environment by way of restoration with a 10% net gain, to uphold the surrounding biodiversity (Planning Advisory Service, 2022). The extent of this can be minimised by creating construction plans with careful consideration to make as few biodiversity losses as possible.

Sphagnum Moss (Peat Bog)

Sphagnum moss is a 'bog-moss' that natively grows in abundance in wet locations such as peat bog and moorland. While seemingly insignificant the main characteristics of the moss that make its presence on the site concerning are that it is both, carbon-rich (Learey, 2021) and acidic (Polygon Group, 2022). Since the base of the turbine is to be composed of steel reinforced concrete Sphagnum Moss, due to its acidity, poses a huge threat to the concrete's integrity. Constructed concrete can generally only tolerate a water pH level of 6.5 or above, tending towards neutral or alkaline rich waters (Any exposure to a pH under 6.5 will cause the concrete to deteriorate, with deterioration increasing as the pH tends lower and pH levels of 3 or lower being the most harmful (Polygon Group, 2022). When exposed to high levels of moisture in moorland, Sphagnum Moss will decompose into peat moss, which holds a pH

level of between 3.0 - 4.0. (Pannico, 2021). For the concrete base this is terrible as any contact with peat moss will contribute to its deterioration. When this is compounded with expected flooding, which will spread the moss naturally, it becomes hard to see a realistic reality where contact between the turbine structure and peat moss doesn't occur. To avoid this as much as possible it would be extremely pertinent to monitor and remove as much peat bog and sphagnum moss as possible, prior, during and post-construction. This process would then need to be continual to ensure that moss does not unknowingly come back into the turbine's vicinity, and any discovered would need to be traced and removed immediately. Removal of the Sphagnum Moss however then becomes a problem in of itself, as Sphagnum Moss is highly carbon-rich. Sphagnum Moss absorbs carbon from the atmosphere to grow as it decomposes from its base turning into peat moss (Learey, 2021). The moss also acts as natural flood management by '[creating] a dense rough surface over the peat, which slows down the water as it flows across the catchment and into the streams. Storm water is fed into the river system more gradually, which reduces flood risk or severity down in the valleys' (Moors For The Future, 2020). The removal of Sphagnum Moss would be a counterproductive act. If the purpose of constructing a wind turbine is ultimately to promote sustainable development, rather than being purely financial, then there is no reason to remove a naturally occurring carbon reducing plant in service of erecting a source of renewable energy. It would be as logical as removing woodland to place the turbine in its place. In the case of this there is no real mitigation strategy, it would need to be determined whether the Sphagnum Moss was more important to retain than construction of a wind turbine.

Noise and Vibration Pollution

To create as little disaffection between the farmer, livestock, public and natural wildlife, noise and vibration pollution will need to be diminished. This can be achieved by installing a Tuned Mass Damper into the wind turbine tower (Roderick, 2012). As well as abiding by Welsh Government guidance that states the turbine should be constructed at least 500-metres from any building, construction planning will have to account for this 500-metre radius around the farm, determining anywhere within it unviable.

Oil Pollution

Due to expected wear and tear in the turbine and its proximity to numerous watercourses, this needs to be controlled tightly. Often wind turbines due to infrequent servicing will begin to display, cracking, pitting and seal breakages. If oil comes into contact with any of the stream or groundwater, it will become irreparably polluted and will cause harm to both the general environment, farmhouse and livestock. If oil leaks occur due to a lack of maintenance it can be very costly, oil leaks are commonly the result of gearbox issues and if beyond repair for 2MW wind turbine on average will cost £1,600,000 to replace (LAIER, 2022). In an attempt to control this regular assessment both remote and on-site will have to take place with any required maintenance being undertaken immediately. It will further being important to construct the turbine as far away from any watercourse or groundwater as possible.

Aesthetic Devalue

Depending on the location of the turbine it is likely that it will be visible for several miles, aesthetic change caused by wind turbines is the most highly valued effect of turbines by the public (Mattman, 2016), making it imperative to minimise aesthetic loss so much as possible, consideration of the colouration blending and location of the turbine based on purely visibility would need to be factored into construction planning. The maintenance road location will further need to be considered making sure that it does not detract from the aesthetic merit of the Moorside, this can be more easily fixed as shrubbery and/or trees native to the moor can be planted to hide the road, which further has a slightly increased environmental improvement and aids towards compliance with BNG regulations. Due to being on a farm there is likely already a road which would just need extension and improvement.

Natural Resources Wales

Due to the issues discussed above, pollution, animal displacement, biodiversity degradation, public perception on aesthetics, Natural Resources Wales may decide that the project is too detrimental and will not grant a construction permit. In this case, the project will not be able to go ahead.

NPV

NPV over the 27-year lifetime of the wind turbine

Initial Investment: £2,000,000

Discount Rate: 5%

Period	Revenue	Cost	Cashflow	NPV
1	200000	56000	144000	£137,142.86
2	200000	56000	144000	£130,612.24
3	200000	56000	144000	£124,392.61

4	200000	56000	144000	£118,469.16
5	200000	56000	144000	£112,827.77
6	200000	56000	144000	£107,455.02
7	200000	56000	144000	£102,338.11
8	200000	56000	144000	£97,464.87
9	200000	56000	144000	£92,823.68
10	200000	56000	144000	£88,403.51
11	200000	56000	144000	£84,193.82
12	200000	56000	144000	£80,184.59
13	200000	56000	144000	£76,366.27
14	200000	56000	144000	£72,729.79
15	200000	56000	144000	£69,266.46
16	200000	56000	144000	£65,968.06
17	200000	56000	144000	£62,826.72
18	200000	56000	144000	£59,834.97
19	200000	56000	144000	£56,985.69
20	200000	56000	144000	£54,272.09
21	200000	56000	144000	£51,687.70
22	200000	56000	144000	£49,226.38
23	200000	56000	144000	£46,882.27
24	200000	56000	144000	£44,649.78
25	200000	56000	144000	£42,523.60
26	200000	56000	144000	£40,498.67
27	200000	56000	144000	£38,570.16

10 Year NPV: -£888,070.17

27 Year NPV: £108,596.84

Externalities

Wind Reliability:

Due to the unpredictability of future climate, it may be that the level of wind drops for extended periods, under these circumstances the return on investment would fall negative as the project is only just about profitable to begin with. On average a utility scale turbine needs a minimum wind speed of 13-mph (Arnold, 2014). As little a loss as 20% of wind would put the project from a £108,000 profit over a 27-year period, down to a loss of £477,000, with a more reasonable 10% loss of wind still causing a loss of £184,000. The maximum amount of wind loss the project can endure before negative losses is only approximately 3.5%. Over a 27-year period this would only allow for wind energy production to not occur on 1 day every 4 weeks.

NPV Table in case of 3.5% average loss of wind

Period	Revenue	Cost	Cashflow	NPV
1	193000	56000	137000	£130,476.19
2	193000	56000	137000	£124,263.04
3	193000	56000	137000	£118,345.75
4	193000	56000	137000	£112,710.24
5	193000	56000	137000	£107,343.08
6	193000	56000	137000	£102,231.51
7	193000	56000	137000	£97,363.34
8	193000	56000	137000	£92,726.99
9	193000	56000	137000	£88,311.42
10	193000	56000	137000	£84,106.12
11	193000	56000	137000	£80,101.06
12	193000	56000	137000	£76,286.73
13	193000	56000	137000	£72,654.03
14	193000	56000	137000	£69,194.31
15	193000	56000	137000	£65,899.34

16	193000	56000	137000	£62,761.28
17	193000	56000	137000	£59,772.65
18	193000	56000	137000	£56,926.33
19	193000	56000	137000	£54,215.55
20	193000	56000	137000	£51,633.86
21	193000	56000	137000	£49,175.10
22	193000	56000	137000	£46,833.43
23	193000	56000	137000	£44,603.27
24	193000	56000	137000	£42,479.30
25	193000	56000	137000	£40,456.48
26	193000	56000	137000	£38,529.98
27	193000	56000	137000	£36,695.22

10 Year NPV: -£942,122.31

27 Year NPV: £6,095.61

Damage to Turbine/Site:

The NPV as currently calculated does not account for costs incurred from processes and maintenance specific to the site but is more generalised. It does not account for down-time caused by flooding or for any specialist monitoring and removal that would be necessary to maintain the site. There may also be unforeseen costs that cannot be reasonably calculated incurred from damage to either the wind turbine, grid connection (transformer), underground cables or surrounding area. Unpredictable damage can occur from either irregular weather events, members of the public, residents of the onsite farm or livestock. Countering this would mean the employment of appropriate security personnel, costing between £10-25 an hour (Region Security, 2020) (£240-£600 for a 24-hour period.) This then however would only account for purposeful damage/vandalism and cannot not wholly counter any accidental damage or prevent damage from irregular weather events.

Alternative Project Evaluation

Out of all available options that most appropriate evaluation tool I find is payback period, due to its prioritisation of merely recouping an investment rather than focusing on primarily on profit like return on investment and average rate of return. The purpose of the project is at its core to reduce carbon emissions, so profit should be neglected in favour of sustainability to an extent.

For this project the payback period (assuming optimum conditions and no externalities affect profit) is roughly 24-25 years. Carrying out the project with this length of payback period would mean sacrificing personal gain in service of longevity. This isn't a particularly attractive investment.

Recommendation

After reviewing and considering all realistic risks and mitigations, it is my recommendation that the project does not go forward. This not only a financial decision but also comes with concern to the environment. Due to the volatile and unpredictable conditions on the moor there will likely be a lot of unforeseen ramifications of construction. The presence of bog in of itself should be of high concern due the amount of land that the turbine and cabling will take needing constant monitoring and alteration. This depending on the scale of work needed could incur hefty costs and may not be possible at all times depending on severity of flooding and bog movement. Problems that occur from bog/flood could shut the turbine site down for periods of time long enough to siphon the already small ~3.5% wind loss tolerance from the project. The main ecological factor I am concerned with on this project is the presence of Sphagnum Moss on the moorland. The moss not only poses a severe threat to the concrete base of the turbine, but it is also concerning from a carbon reduction standpoint. Since Sphagnum Moss reduces carbon in the atmosphere removing it is wholly illogical and cannot be recommended especially when compacted with the project being almost profitless, making the main function of it then to preserve the environment as opposed to creating a stream of profit for investors. Removing the moss would further cause issue for the project and would increase flooding on the site significantly. Being near so much natural and potential water further does not bode well considering the risk of oil leakage and run-off contamination. The worrying unpredictability of the moorland alongside the very small financial tolerance creates a situation that is far too risky for far too little return. It is extremely likely that the 3.5% wind tolerance would be far too insufficient, as it is reasonable to expect wind speeds of less than the required 13-mph for more than 1 day in a 4-week period. Even if profit were no factor in this project I still would on the illogical basis of removing the Sphagnum Moss not recommend this site and would suggest finding a construction site elsewhere.

References

Crossley, R. (2014) *Wind Turbine Blade Design*. Available at: https://www.researchgate.net/figure/A-Typical-modern-2MW-wind-turbine-specification_tbl5_300904446 (Accessed: 17 November 2022)

Britannica (2022) *Moor*. Available at: <https://www.britannica.com/science/moor-grassland> Accessed: (17 November 2022)

Natural Resources Wales (2020) *Construction company fined for polluting watercourse*. Available at: <https://naturalresources.wales/about-us/news/news/construction-company-fined-for-polluting-watercourse/?lang=en> (Accessed: 17 November 2022)

Natural Resources Wales (2022) *Riverside property owners – know your rights and responsibilities*. Available at: <https://naturalresources.wales/flooding/managing-flood-risk/riverside-property-owners-know-your-rights-and-responsibilities/?lang=en> (Accessed: 17 November 2022)

Checkatrade (2022) *Water pump price*. Available at: <https://www.checkatrade.com/blog/cost-guides/water-pump-price/> (Accessed: 21 November 2022)

Sivaraja, Y. (2021) *Drying out a Transformer after a flood*. Available at: <https://www.linkedin.com/pulse/drying-out-transformer-after-flood-yuzishan-sivaraj> (Accessed at: 30 November 2022)

British Ecological Society (2019) *Wind turbines causes functional habitat loss for migratory soaring birds*. Available at: <https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2656.12961> (28 November 2022)

Planning Advisory Service (2022) *Biodiversity Net Gain for local authorities*. Available at: <https://www.local.gov.uk/pas/topics/environment/biodiversity-net-gain-local-authorities> (Accessed: 28 November 2022)

Polygon Group (2022) *How Humidity and pH Affect Concrete Degradation*. Available at: <https://www.polygongroup.com/en-US/blog/how-humidity-and-ph-affect-concrete-degradation/#:~:text=As%20the%20pH%20of%20acids,the%20more%20porous%20it%20becomes> (Accessed: 17 November 2022)

Learey, A. (2021) *Why are our moors so damaged?* Available at: <https://www.thebmc.co.uk/why-are-our-british-moors-so-damaged> (Accessed: 17 November 2022)

Pannico, A. (2021) *Effect on Chemical and Physical Properties of Soil Each Peat Moss, Elemental Sulfur, and Sulfur-Oxidizing Bacteria*. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8469801/#:~:text=Peat%20moss%20is%20a%20corroded,growth%20when%20mixed%20with%20soil> (Accessed: 17 November 2022)

Moors For The Future (2020) *“Superhero” sphagnum moss reduces flood risk*. Available at: <https://www.moorsforthefuture.org.uk/the-latest/recent-news/moorlife-2020/superhero-sphagnum-moss-reduces-flood-risk#:~:text=As%20the%20sphagnum%20grows%20and,severity%20down%20in%20the%20valleys> (Accessed: 17 November 2022)

Roderick, C. (2012) *Vibration Reduction of Offshore Wind Turbines Using Tuned Liquid Column Dampers*. Available at: <https://core.ac.uk/download/pdf/13637118.pdf> (Accessed: 30 November 2022)

LAIER (2022) *Oil Leakes in Wind Turbines: The Dirty Side to Clean Energy*. Available: <https://www.laiier.io/use-cases/wind-turbine-oil-leaks#:~:text=The%20problem%20is%20that%20over,so%20leaks%20may%20be%20missed> (Accessed 2 December 2022)

Mattman, M. (2016) *Wind Power externalities: A meta-analysis*. Available at: <https://www.sciencedirect.com/science/article/pii/S0921800915304766#t0010> (Accessed: 30 November 2022)

Arnold, B. (2014) *Collecting and Storing Energy from Wind Turbines*. Available at: <https://www.azocleantech.com/article.aspx?ArticleID=488> (Accessed: 2 December 2022)

Region Security (2020) *How Much Do Security Guards Cost?* Available at: <https://www.regionsecurityguarding.co.uk/blog/security-guards/how-much-does-security-guard-cost/#:~:text=General%20manned%20security%20guarding%20can,the%20protection%20of%20your%20business> (Accessed: 28 November 2022)

[Word Count w/o References + Tables]: 2731