Thank you for your detailed review of our paper. We appreciate your suggestions for areas of further improvement and clarification. Please see our changes listed below.

**Reply to specific comments**

1. The term for the semi-submersible platform type has been changed throughout the paper, from "three column semi-submersible" to "triangular semi-submersible platform with three outer columns and the turbine centrally mounted" or simply the "triangular semi-submersible."

**4.7 Discussion of Results**

The results are useful for upscaling a semi-submersible platform to a larger size, especially as a preliminary design analysis before a more detailed design process. These results are applicable for a semi-submersible platform with three outer columns forming a triangle and the turbine mounted in the center. There are a wide variety of other FOWT designs that would be interesting to study, including more unique semi-submersible designs (e.g., four outer columns forming a square with one central column or the turbine mounted on one outer column instead of the central column), spar designs, and tension-leg platform designs. If a researcher wants to upscale a ~~three column~~triangular semi-submersible platform with three outer columns and the turbine centrally mounted to a size of 6 - 30 MW, this method can give a good estimate of the platform dimensions and mass based on an original design and larger wind turbine parameters.

2.1 Changes have been made regarding the constant wall thickness assumption.

The semi-submersible platforms are upscaled from the IEA design using a scaling factor of $\alpha$ = 0.72 for the platform dimensions, shown in Table 10. The 332 W/m$^2$ specific power, 4.5 cm wall thickness, and 5.9° platform pitch angle are kept constant. Please recall that the wall thickness is 4.5 cm based on the IEA design, in contrast to the 6 cm wall thickness of the OC4 design. The platform mass results would be significantly different if a larger wall thickness was used, if required for greater structural integrity. The ratio of platform steel mass to total platform mass is reduced as the turbines are upscaled; the 15 MW IEA system has 19% steel mass, and the 30 MW IEA system has 19% steel mass compared to total platform mass including ballast. Fitting a curve to the mass data indicates that the platform steel mass is upscaled by $R^{1.4}$ and the total platform mass is also upscaled by $R^{2.2}$. The natural period of the system in pitch increases slightly as it is upscaled.

2.2 That is an excellent point regarding the constant 30 meter gap assumption. This is now briefly mentioned in section 3.4 "upscaling methodology" and 4.3 "case study discussion."

the scaling constant $\alpha$ in Eq. (1), which is increased from 0 to 2 in increments of 0.005. The wall thickness and clearance between the blade tip and the waterline are kept constant during upscaling. The 30 m clearance between the rotor and the waterline was chosen because the literature and industry trends show that the 30 m clearance is typical for offshore wind turbines to date (Robertson, A., Jonkman, J., Masciola, M., Song, 2014; Allen *et al.*, 2020). The system mass, buoyancy, ballast

value that preserves the static platform pitch angle at rated thrust. The results are shown in Table 9. The specific power, draft, clearance between the rotor and the waterline, wall thickness, and platform pitch angle are kept constant. ~~Please recall that the wall thickness is 4.5 cm based on the IEA design, in contrast to the 6 cm wall thickness of the OC4 design. The platform mass results would be significantly different if a larger wall thickness was used.~~ The moment of inertia is shown for the entire system increases more rapidly in part because the draft is increasing while the OC4 draft is constant. There is a 30 m gap between the blade tip and waterline for both case studies, which was kept constant during upscaling. We chose the 30 m gap because of the prevalence of this choice in practice, but this clearance will need to be explored further in future research studies. In particular, the heave motion of each upscaled turbine should be considered to ensure that there is not too large of a downward heave motion towards the waterline in any case, to ensure that the gap is not too small considering wave height and combined platform rotational motions.

## 3.1 An explanation of the choice of the root-finding method has been added to the section 3.4 "upscaling methodology" section.

This method is effectively a root-finding problem to determine the value of $\alpha$ that results in equal rated platform pitch angles for the baseline and upscaled turbines. While it may be possible to solve for a single alpha value analytically, the root-finding approach was selected because it allows us to see trends for the platform behavior. We can clearly see how the upscaling value of $\alpha$ would result in a more conservative or less conservative design. The platform dimensions are upscaled uniformly with

## 3.2 The reference has been added here.

Eq. (4). The pitch natural period is calculated using Eq. (8) (derived from Eq. (5)) to ensure that it is not in the predominant wave period range. The pitch natural period of a semi-submersible platform should always be above 20 s (Det Norske Veritas Germanischer Lloyd, 2017). The added mass coefficient $c_A$ comes from the documentation for each semi-submersible case

## 4.1

of platform steel mass relative to the total platform mass is relatively constant at 19% for the IEA upscaling results (Table 10). In contrast, the percentage of platform steel mass relative to the total platform mass decreases for the OC4 upscaling results (Table 9). Additionally, the IEA platform steel mass scales by $R^{1.4}$ while the OC4 platform steel mass scales by $R^{1.32}$. The

## 4.2 All mention of the OC4 steel mass upscaling now are consistently R$^{1.3}$.

(Table 9). Additionally, the IEA platform steel mass scales by $R^{1.4}$ while the OC4 platform steel mass scales by $R^{1.32}$. The

## 4.3 & 4.4

to ensure the design meets natural period and static pitch angle requirements. Each of these studies use the $RNA$ mass upscaling ratio in order to set the upscaling factor for the platform. Leimeister et al. (Leimeister, 2016) upscales the platform dimensions using a scaling factor of 1.264 for the 10 MW design, and then scaling is adjusted separately for the main column and upper columns. ~~This is the starting point, and then scaling is adjusted for the main column.~~ George (George, 2014) uses a scaling factor of 1.26 for the 10 MW design, based on the mass scaling. For the 10 MW upscaling results, the other three studies all

## 4.5 There is a brief conclusion added to the end of the 4.6.2 sensitivity study section.

when the $RNA$ mass is reduced by 50%, the destabilizing stiffness term is reduced by 35%. The $RNA$ mass impacts the upscaling results, but the sensitivity study shows that it is reasonable to assume the constant $R^{2.2}$ $RNA$ upscaling within the scope of this study.

## 4.6 The suggested changes have been made to both section 4.7 "discussion of results" and section 5 "conclusion."

The limitations of this method include the simplifications assumed in order to identify the upscaling trends. The dynamics of the FOWT system needs further evaluation, including second order effects. However, this study chooses to focus exclusively on the platform pitch motion during rated thrust, as this has been shown to be the primary load case. Additionally, environmental conditions such as wind wave misalignment are not considered in this case. The purpose of this research study is to identify the upscaling trends using the simplified assumptions, and leave further evaluation of detailed design to future research studies. The benefit of this method is identifying an upscaled design with little computational time and expense. Future work should validate the upscaled FOWT designs using OpenFAST, which involves creating a turbine and platform model for each upscaled design. Additionally, future research is needed of the structural integrity of the FOWT platform assuming constant wall thickness with upscaling. The constant clearance assumption between the blade tip and waterline would also be beneficial, in addition to checking the heave motions of future research studies to ensure that heave motions are within a reasonable range for platform motions. A better understanding of the upscaled designs in extreme wind and wave conditions

can further the knowledge of platform upscaling. An additional area of future work is to conduct cost of energy analysis, in order to gain insight into how turbine and platform scaling impact the system economics. Upscaling the platform with a constant wall thickness causes the platform steel mass to increase with a factor of approximately $R^{1.5}$, suggesting that larger turbines may be advantageous. But a more nuanced and detail analysis is needed, which includes balance of system costs and estimates on annual energy production, to assess the likely impact of continued upscaling of FOWTs.

are used instead of upscaling. Thus, platform upscaling is shown to be advantageous regarding platform steel mass cost savings as compared to installing multiple, smaller FOWT systems. Having fewer, larger FOWT systems will improve other aspects of offshore wind farms, such as fewer turbines to install and maintain in difficult to access ocean environments. However, there will likely need to be an upper limit to FOWT upscaling, likely related to the increased stresses due to blade weight that continue to scale linearly with rotor radius.

~~Future work should validate the upscaled FOWT designs using OpenFAST, which involves creating a turbine and platform model for each upscaled design. A better understanding of the upscaled designs in extreme wind and wave conditions can further the knowledge of platform upscaling. An additional area of future work is to conduct cost of energy analysis, in order to gain insight into how turbine and platform scaling impact the system economics. Upscaling the platform with a constant wall thickness causes the platform steel mass to increase with a factor of approximately $R^{1.5}$, suggesting that larger turbines~~

## Reply to technical corrections

- The Leimeister reference has been corrected in the three places that you mention.
- All notation and abbreviations have been checked.
- The equations have been simplified by removing brackets.
- All tables have been checked so that size 9 cambria math font is used and there are no bold headers. The information is shown across rows rather than down columns, except in places where information is changing in rows and columns (tables 1 (from reference), 8-13, 16). The color has been removed from table 8.
- The modern wind turbine rating has been updated in the abstract.
- The abbreviation for NREL has been introduced.
- The numbers and units are together, and not split between lines.
- The mention of “Section 4.6.1” has been capitalized.
- The rotor nacelle assembly is now only defined once, on line 203.
- The comma has been added to 1,025 kg/m$^2$.

- The unit has been added to- 13.46 m.
- “Upscaling factor” has been corrected.
- The abbreviation “Sect.” should be used within the text, I have modified places that read “Section”. This is now in line with the journal’s guidelines.
- There is no longer bold used in table 9, or any other table. Rotor radius is no longer introduced in table 9.
- The “to” has been added in line 449.
- The natural period abbreviation “Tn” is now introduced in line 231, and used throughout the paper.
- The grammatical mistake on line 581 has been changed.