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Interactive comment on "Simulation of an offshore wind farm using fluid power for centralized electricity generation" *by* Antonio Jarquin Laguna

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Author response to reviewer #1

Thank you to the reviewer for the comments on the paper. The specific replies to the reviewer comments [RC1] are addressed by the author [AC] in the following lines with respect to the revised version:

1. [RC1] "The paper should probably mention (e.g. in a footnote) that it is an extended and updated version of a paper previously presented at TORQUE2016 conference, and published in IOP Journal of Physics: Conference Series."

[AC] As this paper was invited for the special Issue on The Science of Making Torque from Wind (TORQUE) 2016, this was not considered necessary following the example

of the other papers submitted for this special issue. The author will comply to the editors instructions.

2. [RC1] "Continuing from the previous item, the paper needs to contain at least 40 percent new content, which is currently not the case."

[AC] The revised version includes now a more detailed explanation of the motivation of the proposed concept together with opportunities for cost reduction. A expanded description of the different models employed, new figures and schematics are now included. The details and description of the controller are added with respect to the conference paper. New results are also presented in the form of an extra case scenario where the hydraulic wind farm is simulated while two turbines are brought to a full stop. The new results give better insight on the behaviour of the hydraulic model in particular with the proposed pressure controller (See also Figures 18 and 19). The conclusions also include further work. More references were also employed in the revised version

3. [RC1] "Introduction: 'This paper continues with previous work' - It would help the reader if the scope and achievements of the previous work were briefly reported. That way the research is placed more into context, and it becomes easier to evaluate what is new here."

[AC] The author agrees, similar comment was done by RC2. The following paragraph has been added: The modelling and analysis of a single turbine with hydraulic technology has been previously presented for variable-speed control strategies. Simulations of an individual turbine with an oil based hydrostatic transmission have been presented in (Jarquin Laguna et al., 2014). The results showed good dynamic behaviour for turbulent wind conditions where reduced fluctuations of the drivetrain torque and power are obtained despite the reduced energy capture. The integration of a single turbine with a Pelton runner using water hydraulics was introduced in (Jarquin Laguna, 2015), where a passive variable speed strategy was proposed. However, the addition and simulation of more turbines to the hydraulic network was not included. In an effort to

assess the trade-offs implied by the proposed hydraulic concept, this paper extends the time-domain simulations to evaluate the performance and operational parameters of five turbines coupled to a common hydraulic network for a hypothetical wind farm with centralized electricity generation. In the first part of this work, an overview of the wind farm model is presented together with the control strategy of the hydraulic components; the second part describes a case example where the results are compared with those of a typical wind farm based on conventional wind turbine generator technology.

4. [RC1] "Are there any system effects when running the concept with more than one turbine? The performance and results obtained for the wind farm should be compared (in a meaningful way) with results for a single turbine.

[AC] That is correct, the system effects are better illustrated in the extra case scenario included in the revised version where two turbines are brought to a full stop during above rated wind conditions, see description in section 4.4

5. [RC1] "The concept is based on the use of seawater. I assume that corrosion becomes an important issue then. Does the author have some comments for the readers on this? "

[AC] The following paragraph and reference has been added in the introduction: In the proposed concept, an open-loop circuit is considered (i.e. the fluid is not circulating) with seawater as hydraulic fluid. The choice of seawater as hydraulic fluid is preferred because of its availability and environmental friendly nature when compared to oil hydraulics. It is important to consider that seawater contains a high concentration of minerals, which give it a high degree of hardness. It also contains dissolved gases such as oxygen and chlorine which cause corrosion. Despite its corrosive nature, the use of seawater hydraulics has already been used in some industrial applications, where in terms of safety, water hydraulics might be preferred due to potential fire hazards or risk of leakage as is the case of the mining industry. An example in the offshore industry includes the seawater hydraulic system for deep sea pile driving incorporating high

pressure water pumps (Schaap 2012). A key advantage of this system is that the use of an open loop circuit cancels the need for cooling equipment, a disadvantage is that it is likely that filters have to be cleaned more frequently.

M. Schaap. Seawater Driven Piling Hammer, IHC Hydrohammer. In Proceedings of the Dutch Fluid Power Conference in Ede, September 2012. (reference added)

6. [RC1] "As it is proposed to use only one turbine and generator, reliability of these becomes a critical issue. Has the author any thought on this that he would like to share with the readers?"

[AC] Indeed, by using only one or a few turbines and generators, the reliability of these components become an important aspect. Modern hydro-turbines have been developed with typical capacities of 500 MW operating for decades with enough operational and maintenance experience gained from conventional hydro-power plants. On the other hand using hydro turbines in combination with renewable energy sources such as offshore wind energy has not been explored. The concept itself is still in predevelopment phase and therefore there is a lack of real data supporting the reliability. It is also expected that by having the whole electrical generation equipment in one offshore central platform instead of having it in a constraint space hundred meters above sea level, would have a positive impact regarding O&M costs.

7. [RC1] "Eqs. 6-7: The notation is slightly confusing. I assume that V(e) is a function depending on the variable e, later shown in Eq. 8. However, also other terms in Eqs. 6-7 are functions that depend on parameters. To be consistent, I suggest that you simply use V in Eqs. 6-7 and clarify V(e) = eVp;max in Eq. 8."

[AC] Equations have been modified accordingly.

8. [RC1] "Section 2.1.3: The pitch actuator model is based on a proportional regulator. Why not also a derivative or integrator component? Why is the pitch actuator model needed?"

[AC] The pitch actuator model is needed to account for any blade-pitch actuator dynamic effects. This means the slow or fast response of the pitching mechanism to the control command signal. The derivative or integrator components are considered to be included in the pitch control which is in series with the pitch actuator, see Section 3.3.

9. [RC1] “Section 2.3: The nozzle length Lnz should be indicated in Figure 4 as well.”
[AC] Figure 4 is now modified including Lnz

10. [RC1] “Section 2.4: What is the value of the vena contracta coefficient used here?”
[AC] A value of Cv=0.99 was used according to (Thake, 2000). Please note that the vena contracta phenomenon does not influence the nozzle efficiency.

Thake, J. The Micro-hydro Pelton Turbine Manual. Practical Action Publishing, 2000. (reference added)

11. [RC1] “Section 3.1: ‘A low pass filter on the pressure measured is employed’ What are the filter characteristics?”

[AC] A first order low pass filter was used with the following transfer function form: LPF(s)= 1/(1+s/wc) where the cut-off frequency wc was set at 32pi [rad s-1]. This description is now included in the manuscript. Table 1 was added with the parameters of the augmented controller.

The author hopes that the modifications to the manuscript and replies to the reviewers satisfy your requests.

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