JOURNAL OF COASTAL AND HYDRAULIC STRUCTURES

Review and rebuttal of the paper

Feasibility of Pumped Hydro Energy Storage in a River Cascade: Case Study of the Meuse

Jan Willem Lambach, Jeremy D. Bricker and Miroslav Marence

Editor handling the paper: Carsten Thorenz

Review Round 1

Reviewer A:

Interesting topic, and well-organized paper, with clear parts. The conclusion is rather a summary. Separate summary and conclusion. Separate results and conclusions about simple hydropower and pumped storage.

Improve methodology explanations: calculation in part 2.4 are not detailed enough, define precisely all the used concepts for example: « FDC day », capactity factor.

Environemental impact: to assess or to comment, for example problems due to discharge blockage, submersions. Time of pumping (night?).

Cost assesment: nothing about the costs of underwater work or cofferdam construction.

Economic assesment: only for one weir and for hydropower. Need for an assesment of the whole river system including pumped storage and costs of surplus energy used to pump

Reviewer B:

The paper deals with the feasibility of retrofitting several weirs in a river cascade of the Meuse with Archimedes' screws to pump and turbine water for electricity production and improved ship navigability. The topic is of interest to the field. However, the novelty is not sufficiently described, and the novel aspects not clearly written in the abstract. The objectives are clear, but there is a need to improve the methodology and to present it clearly in the paper. This includes more data, calculations, and precise explanations. Many technical details are not clear and implausible. The interdependences using several screws are not clearly discussed, as well as the low head. Illustrations and tables must be improved. The citation style is not consistent. Please, find the comments attached.

Editor's remarks:

We have reached a decision regarding your submission to Journal of Coastal and Hydraulic Structures, "Feasibility of pumped hydro energy storage in a river cascade - case study of the Meuse".

We decided that you need to resubmit your paper after major revisions.

Please revise your paper considering the remarks and needs of modifications of the reviewers and provide a description of your revisions in an extra file. In this text the consideration of all reviewers' remarks and proposals must be addressed.

Apart from the reviewer's remarks, the section editor has the following concerns:

Minor comments:

- The quality of most graphics is not sufficient

- The figure captions have an erroneous "|"

- Figure 1 is not really informative and not a topographic map. Height information is missing.

- Citation style is not always consistent with the template.

- References list is not clean.

- Citations from "Lambach 2021" are partially not clear: Graphics can not be found at the described place in the cited document (master thesis). E.g. figure 10, "Lambach, 2021, p. 88".

Major comments:

Parts of the article are rather weak in their depths. Chapters 2.2, 2.3, 2.5 do not really describe "methods".

Same figures are partially redundant (figure 2 and 7; figure 6 and 9) or have a low information content (figures 1 and 4).

The considerations about the possible water storage do not sufficiently take side effects into account: What about land usage of the flood plains? Ecological impact of the flooding? Maybe impact on ship traffic?

Large parts of the article offer the same information as already presented in "Lambach 2021". As this is already published information, the article should show a substantial additional value over the previously published information and clearly focus on that additional information.

Rebuttal:

• *'The abstract needs a better structure and the English language can be improved, using conjunctions etc.'*

This had been taken into account, abstract has been clarified, partly rewritten and divided into four parts. A rewritten sentence, or new information is marked in yellow. Previous sections or sentences are marked like this: previous sections or sentences

• *'more precise would be directly Archimedes' screw. Pump-turbines can be easily misunderstood.'*

In order to clarify the use of pump-turbines/Archimedean screw the second part of the abstract has been adjusted.

• *'Same here. Are Archimedes screw really called pumped-storage-plants?'*

This has been clarified in the text.

• *'Must be defined. Previously pumped water flowing through the turbines counts in the calculations here? So, the used energy is not subtracted?'*

This has been completely rewritten, in order to make this more clear. Additional information has been added.

1 Introduction

• *'better cite the authors, also in the following text'*

("Lijst van waterkrachtcentrales", 2021) is a citation to a webpage of which the author is unknown. How to citate a webpage according to APA-rules has been subject of discussion when writing the thesis. Therefore, the APA Format Citation Guide from Mendely has been used which explains: 'Author unknown. If this is the title of a webpage it should be in quotation marks. For example: ("APA Citation", 2017).' However, to make the citation more consistent the quotation marks could be skipped as there is conflicting information. The book Rapportagetechniek provided by TU Delft instructs not to use quotation marks and make it: (Lijst van Waterkrachtcentrales, 2021). Please let me know what you as reviewers prefer.

• *'quality must be improved'*

The quality of figure 1 has been improved. However, the pdf should be set at size 100 %. When decreased to 80% the figures become vague.

• *'please, be consistent in the citation style'*

APA rules are used as explained. Sentence has been clarified in: Using information from Rijkswaterstaat, Beurskens & van Dongen (2018) and Pixabay (2021) Figure 2 was created. The information from Rijkswaterstaat was provided during an interview.

• *'quality must be improved'*

Figure 2 has been improved. Table 1 has been included in Figure 2. Pdf should be set at size 100 %. When decreased or enlarged the figure become vague. 2

• *'this table could be included in the figure before'*

Table has been included in Figure 2.

• *'do not write pumped storage plants always in a different way. As commented before, naming Archimedes' screws directly would be more precise.'*

This has been clarified. The words 'Pumped Storage Hydropower plant' are now used consistently. 'Pumped Storage Hydropower plant' is used quite common internationally. Also 'Pumped Storage Hydroelectricity facility' is used internationally, but we chose 'Pumped Storage Hydropower plant'

abbreviated to ‘PSH-plant’. The structure of the article is such it builds up to paragraph 3.2 ‘pump-turbine selection’ in which it is briefly discusses the Archimedean screw has been selected as pump-turbine. However, for clarification the screw has been named directly in this introductory paragraph.

• *‘remove last Section (breakdown of article)’*

This part has been removed.

• *‘The whole methodology chapter can be shortened. It is confusing as a reader. It seems everything is written, just the short number of the result not. And therefore, is coming a whole new chapter, that also does not have the numbers in it. The methodologies that should be explained more in detail are method 1 and 2.’*

For the structure of this article the example of the JCHS-webpage has been used, which shows:

- a paragraph outlining the methodology

- followed by a separate paragraph presenting the results.

However, the methodology has been shortened as much as possible and is just briefly outlined. Information related to results has been transferred from paragraph 2 ‘methodology’ to paragraph 3 ‘results’ in order to avoid confusion for the reader. Method 1 and 2 are described more in detail in paragraph 3. Furthermore, the methodology has been rewritten in a more open way such it makes sense the results are presented in paragraph 3. ‘Pump-turbine’ is mostly rewritten in ‘Archimedean screw’.

• *Subparagraph 3.1 Hydraulic boundary conditions ‘where are they?’*

Source is added: ‘For details look at Lambach (2021, p. 19)’. To avoid an overkill of information these four FDC’s are not all shown in the article. Only the FDC for the Sambeek weir in combination with the water levels up-and downstream is presented in the article.

• *‘quality must be improved!’*

The quality of this FDC figure has been improved. It is taken directly out of Python, it cannot become sharper.

• *‘quality must be improved!’*

The quality of this river cross-section figure has been improved. Pdf should be set at size 100 %. When decreased or enlarged the figure become vague.

• *Section 3: ‘details must be explained. Numbers!’*

This Section has been rewritten and clarified. More information is added. However, to present a calculation on the time of approximately 4 hours it will last for the river to fall dry at Borgharen is not included, it is referred to. This calculation itself does not add much to the essence of the article. But to avoid questions like ‘Okay, how long will it last before the river will fall dry during pumping?’ the mentioning of this time period of 4 hours is considered to be relevant.

Subparagraph 3.2 Pump-turbine selection

Information from the Methodology paragraph 2 has been transferred.

Subparagraph 3.3 Conceptual design

Information from the Methodology paragraph 2 has been transferred for clarification purposes. Transferred and rewritten sentences are marked in yellow.

• *'that is obvious'*

Sentence has been shortened.

• *'improve figure!'*

The figure has been snapped shot again and decreased in size to get a better resolution. But it cannot become clearer like this. Pdf should be set at size 100 %. When decreased or enlarged the figure become vague.

• *'explain named rules'*

Additional information on these relevant rules of thumb considering caisson construction, like for instance wall- and slab thickness, is added.

Subparagraph 3.4 Meuse model

Information from the Methodology paragraph 2 has been transferred. Furthermore, multiple boundary conditions are described which are incorporated in the model, like for instance:

- The pumped volume at each weir (with the exception of the most downstream PSH-plant at Lith) is bounded by the volume pumped up at the weir further downstream, in order to avoid a decrease in water level.

- etc., see article.

• *'quality must be improved! Is the figure really needed?'*

This figure has been removed.

• *'quality must be improved. No black background. Use other software, like Matlab e.g'*

New figure with higher quality has been made using Python. It is taken directly out of Python, it cannot become sharper. Please keep the pdf at size 100 %.

• *'why is this power plant used?'*

We need a reference in terms of AEY and number of households which is applicable to the Dutch case. Sentence in de article has been clarified, Borsele is left out.

• *'please, discuss the fully changed flow conditions'*

This is explained in the previous Section. There is more room for storage using more screws for the downstream weirs. So flow conditions change: compared to method 1 at a relatively high river discharge there is still room for energy storage, mainly downstream the cascade.

Added: As the PSH-plant is placed more parallel more turbulence and energy losses are expected. However, this is neglected in the model. The flow conditions accounted for in the model are changes in water levels up-and downstream and the varying discharge. For more detailed information see Meuse model (Lambach, 2021). As this article is based on a thesis this is the information on flow conditions available. In the thesis no hydrodynamic analysis or whatsoever was performed. The source of the Meuse model has been added in the list of references. In paragraph 3.4. a reference to an extensive elaboration on the computations on hydropower and energy storage and interrelationship of the weirs based on the boundary conditions for two different days in the FDC, namely day 252 (average river discharge 66 m^3/s) and FDC day 315 (average river discharge 26 m^3/s) is made for the interested reader. These computations demand so many pages to describe it is thought to be an overkill of info in the article.

• *'comparing- wind and hydropower is not useful. But if so, please compare Wh'*

As this article is about using surplus power for energy storage a comparison is made to a windfarm which can produce surplus energy. This has been clarified in the article, including more information on GWh.

Subparagraph 3.5 Cost

Information from the Methodology paragraph 2 has been transferred.

• *'the discharge does not seem to fit the system'*

The sentence has been clarified, discharge per screw (15 m^3/s) and discharge in total (300 m^3/s using 20 screws) is mentioned.

• *'This is farfetched comparison'*

It is farfetched, but this is the closest information we could find considering preparation and running cost.

• *'Why'*

A PSH-plant with multiple screws of this diameter does not exist yet around the globe. Therefore, reference information is hard to find. So economies of scale are mentioned but neglected in the calculation. Furthermore, only a rough estimation of the specific cost of the project is presented as the essence of the article and underlying thesis comprises the hydraulic assessment of utilizing the hydropower- and energy storage potential of the Meuse. It is not an extensive economic assessment.

• *'?' and 'it is hard to compare the fish mortality of one turbine, using e.g. bypass systems and racks to a huge amount of screws. More details are needed here.'*

Fish mortality is usually measured on a turbine without racks or bypass systems or anything else. By doing so one can compare the fish mortality rates and decide on what measures to take. This information has been added in the article in subparagraph 3.2. The mortality rates of Francis (30%) and Kaplan (10%) turbines are also mentioned in paragraph 3.2 in order to compare. In this subparagraph 3.5 a sentence is added which refers to paragraph 3.2. In the thesis bypass systems and the use of racks are elaborated on. Racks are considered not to be economic by the energy company

Vattenfall which operates two hydropower plants in the Meuse. The fish bypass system of Fishflow Innovations failed. So, only the Migromat fish migration detection system is used in the Meuse. This is considered to be background information not really necessary for the article.

Review comments in general

Apart from the reviewer's remarks, the section editor has the following concerns:

- *The quality of most graphics is not sufficient*

Quality figures and graphics has been improved. At pdf size 100 % the resolution should be fine. However, when shrinking to 80 % resolution quality decreases.

- *The figure captions have an erroneous "|"*

See discussed at paragraph 1. ("Lijst van waterkrachtcentrales", 2021) is a citation to a webpage of which the author is unknown. How to citate a webpage according to APA-rules has been subject of discussion when writing the thesis. Therefore, the APA Format Citation Guide from Mendely has been used which explains: 'Author unknown. If this is the title of a webpage it should be in quotation marks. For example: ("APA Citation", 2017).' However, to make the citation more consistent the quotation marks could be skipped as there is conflicting information. The book Rapportagetechniek provided by TU Delft instructs not to use quotation marks and make it: (Lijst van Waterkrachtcentrales, 2021). Please let me know what you as reviewers prefer.

- *Figure 1 is not really informative and not a topographic map. Height information is missing.*

The authors think Figure 1 provides information, as it shows the location of the Meuse river and its weirs in the Netherland. Height information on weirs is included in Figure 2.

- *Citation style is not always consistent with the template.*

APA rules were used. Please comment on this, see above.

- *References list is not clean.*

The references throughout the article have been checked. Reference list has been checked. It seems to be okay. A source on the Meuse model is added.

- *Citations from "Lambach 2021" are partly not clear: Graphics cannot be found at the described place in the cited document (master thesis). E.g. figure 10, "Lambach, 2021, p. 88".*

This has been checked and corrected.

- *Sections of the article are rather weak in their depths. Chapters 2.2, 2.3, 2.5 do not really describe "methods".*

For the structure of this article the example of the JCHS-webpage has been used, which shows:

- a paragraph outlining the methodology

- followed by a separate paragraph presenting the results.

Therefore, this article uses the same structure as JCHS. However, the methodology has been shortened as much as possible and is just briefly outlined. Information related to results has been transferred from paragraph 2 ‘methodology’ to paragraph 3 ‘results’ in order to avoid confusion for the reader. Information is added: method 1 and 2 are described more in detail in paragraph 3. Furthermore, the methodology has been rewritten in a more open way such it makes sense the results are presented in paragraph 3. ‘Pump-turbine’ is mostly rewritten in ‘Archimedean screw’. Additional information on boundary conditions related to the model at the paragraph ‘Results’.

- Same figures are partly redundant (figure 2 and 7; figure 6 and 9) or have a low information content (figures 1 and 4).

Figure 1 has been topic of discussion. We decided to leave it in. For a reader in let’s say Japan with no topographical knowledge of the Netherlands it could be nice to see the course of the Meuse river. Figure 7 has been removed. An elaboration on Figure 7 Power graphs method 1 is added. FDC is included. Including two figures of power graphs is discussed, but thought to be relevant: it shows the differences between method one and two graphically. It underlines the higher room for energy storage in method 2. Presenting two figures of the PSH-plant is thought to be relevant as well. It shows the consequences for the environment when applying method 2 resulting in 36 screws at Sambeek: the PSH-plant has to be placed more parallel to the river instead of perpendicular. This will certainly hold for the downstream weirs Grave (48 screws) and Lith (59 screws).

- The considerations about the possible water storage do not sufficiently take side effects into account: What about land usage of the flood plains? Ecological impact of the flooding? Maybe impact on ship traffic?

In the article it is explained in subparagraph 3.1. the storage volumes in the Meuse cascade are bounded by the summer dikes, as the floodplains serve agricultural purposes. So the floodplains are not used for storage in method 1 and method 2. However, in subparagraph 3.4.3 Increased storage volumes including floodplains are briefly assessed. One can read: ‘It is questionable if a Meuse cascade with enlarged storage sections is feasible as it will probably require unrealistic investments, and will have a major impact on the environment. This question might serve an objective of further research.’ Ship traffic is not influenced by energy storage or hydropower. Ships have to pass the locks in the Meuse river anyway. At peak discharge there is no head difference anymore and the ships can freely sail the river. At peak discharge there will be no hydropower or storage as there is no head so no conflict for ships.

- Large sections of the article offer the same information as already presented in "Lambach 2021". As this is already published information, the article should show a substantial additional value over the previously published information and clearly focus on that additional information.

What I (Lambach) was told when asked to write an article about my thesis is it should be a representation of the thesis. Furthermore, the thesis is not published in a journal or whatsoever, it is freely downloadable from the TU Delft repository. The thesis is used to refer to in this article, for the interested reader who wants more detailed information, for instance on computations of the Meuse model.

Reviewer B:

Interesting topic, and well-organized paper, with clear sections

- The conclusion is rather a summary. Separate summary and conclusion

The example of JCHS was used to structure the article. Therefore, there is no separate summary and conclusion. Furthermore, when writing the thesis I (Lambach) was explicitly forbidden to present a summary. I was supposed to only present the major conclusions.

- Separate results and conclusions about simple hydropower and pumped storage

This would ask for separate power graphs and we think this will lead to confusion. Using one graph for hydropower and storage shows the implications when the river discharge improves: the higher the discharge the higher the contribution of hydropower, and the less room for energy storage. Furthermore, the combined capacity factor for storage and hydropower is presented in the bullets with results for method 1 and the results for method 2 etc. Therefore, we think it's more clear to present it like this.

- Improve methodology explanations: calculation in section 2.4 are not detailed enough, define precisely all the used concepts for example: « FDC day », capacity factor

In the thesis of Lambach an extensive elaboration on the computations on the volume balances and their interrelationships per weir is presented for FDC day 252 (river discharge 66 m^3/s) and FDC day 315 (river discharge 26 m^3/s) These computations cannot be summarized to implement in the article, then they still will ask for multiple pages. Therefore, a reference is made in subparagraph 3.4.1 for the interested reader. The computations on volume balances for flow duration curve day 252 are shown at the end of this document, to get an idea of the extent of the computation. FDC-day is explained more detailed at subparagraph 3.1. Capacity factor is explained at subparagraph 3.4.1

- Environmental impact: to assess or to comment, for example problems due to discharge blockage,submersions. Time of pumping (night?)

The article is a representation of the thesis of Lambach, in which no environmental impact analysis was performed. Therefore, this has not been done in this article. Environmental concerns are topics for further research. Time of pumping during storage mode is 8 hours. This is mentioned in the article. During nighttime the demand for energy is generally he lowest.

- Cost assessment: nothing about the costs of underwater work or cofferdam construction

Preparation and cost of design and control (running cost) have been estimated to be 20 % of the cost of civil-and electrical/mechanical work. It is assumed this is including the cost of underwater work and cofferdam construction.

- Economic assessment: only for one weir and for hydropower. Need for an assessment of the whole river system including pumped storage and costs of surplus energy used to pump.

An economic assessment is not included in the thesis of Lambach which forms the basis of this article. However, as we wanted to say something about cost the authors decided to apply the concept

of specific cost. So only a rough estimation of the specific cost of the project is presented. The concept of specific cost comprises all construction costs divided by the installed capacity resulting in euro/kW. This is a generally used concept in the field of hydropower engineering. It does not take into account operational cost, like the cost of surplus energy for storage or cost of maintenance and control. Specific cost for hydropower and storage are equal, as they both will use the construction cost divided by the installed capacity.

Review Round 2

Reviewer A:

The answers and explanations to my comments are satisfying. The paper is improved.

Reviewer B:

The changes in the paper are clearly visible, but the folowing still needs to be adressed:

- The abstract must be rewritten. The central theme does not get clear and the abstract is not well organized. The novel aspects are not clear.

- The chapters must be reorganized. The chapters exist twice in method and results and it is not clear why.

- The methodology chapter must be improved and the method must be explained better. Explain the pump-turbine selection more detailed.

- Discussion and conclusion must be written more consistent and efficient.

- The novelty of the study is not clear and must be pointed out.

- The quality of the figures must be improved. Especially figures 1, 3, 4

Editor's remarks:

We have reached a decision regarding your submission to Journal of Coastal and Hydraulic Structures, "Feasibility of pumped hydro energy storage in a river cascade - case study of the Meuse".

We decided to request revisions. Please revise your paper considering all remarks of the reviewers carefully. Additionally, a table that includes each reviewer's remark and your concerning consideration is needed in an extra file. It should be sorted by reviewers.

Comments of the editor:

The quality of the graphics is still (!) weak. You should check (in this sequence):

- within Word, there are options in the general settings specifying that images should be compressed during import. Disable that and reimport images.

- upscale images to X2 or X4 resolution with a high quality upscaler before importing

- export PDF in higher quality and provide also the Word file

Furthermore, I agree with the reviewer, that Chapter 2 "Methods" is rather sparse and furthermore it is misleading, that the header names, e.g. "Boundary conditions" are partially the same as in the much longer Chapter 3 "Results". Strangely, within Chapter 3 there are again subchapters with "methods". Please reorganize and enhance Chapter 2.

Concerning the main focus: In abstract, introduction and conclusions it should be made more clear what the goal of the study was: Evaluate the general concept of pumped-storage for the Meuse? Or show the applicability of Archimedes screws?

Rebuttal:

In general, the article has been completely rewritten. It has been tried to make it more concise. Clarifying information has been added at some points. Irrelevant information has been removed.

Comments of the editor:

The quality of the graphics is still (!) weak. You should check (in this sequence):

- within Word, there are options in the general settings specifying that images should be compressed during import. Disable that and reimport images.

This has been done.

- upscale images to X2 or X4 resolution with a high quality upscaler before importing.

The quality of the images and the resolution has been improved. Fig 1, 2 and 4 are improved/created in Photoshop instead of Paint. In Photoshop a high resolution X4 has been applied. Fig 3, 7 and 9 are created using more dots per inch leading to a better and higher resolution.

- export PDF in higher quality and provide also the Word file.

This has been done using a PDF tool which should preserve image quality. The size of the files was three times bigger after using the PDF-tool.

- Furthermore, I agree with the reviewer, that Chapter 2 "Methods" is rather sparse and furthermore it is misleading, that the header names, e.g. "Boundary conditions" are partially the same as in the much longer Chapter 3 "Results". Strangely, within Chapter 3 there are again subchapters with "methods". Please reorganize and enhance Chapter 2.

Chapter 2 and chapter 3 haven been combined to avoid any confusion. So there is only one chapter 2 ‘Methodology and results’. This chapter starts with a brief overview of the methodological steps 1, 2, 3, 4 and 5. Then these methodological steps are elaborated on in separate subparagraphs which also directly show the results. With respect to the remark on subchapters with “methods”: this means two methods have been applied to determine the number of screws per PSH-plant. A method using the design discharge (method 1) and a method using the maximum volume a PSH-plant has to pump (method 2). Therefore, in step 3 of the methodology in the introduction of Ch2 it reads: ‘The number of pump- turbines is determined using two methods: design discharge (method 1) and maximum volume to pump (method 2).’

- Concerning the main focus: In abstract, introduction and conclusions it should be made more clear what the goal of the study was: Evaluate the general concept of pumped-storage for the Meuse? Or show the applicability of Archimedes screws?

Abstract, introduction and conclusions have been clarified and rewritten. The main goal of this study is to assess the possible utilization of the full energy storage- and hydropower potential of the Meuse cascade within Dutch environmental regulations. So main focus is to evaluate the general concept of pumped-storage in the Meuse. Main goal has been added in abstract, introduction and conclusions. The novelty of this study is the evaluation of the concept of using canalized river sections for pumped-storage purposes within conditions of fluctuating discharge and -water levels throughout the year. Novelty had been added in abstract, introduction and conclusion. To achieve the main goal a pump-turbine is needed. The article builds up to subparagraph 2.2 in which it becomes clear the screw turbine will be used. So showing the applicability of the Archimedean screw is not the main goal, it is a result of the pump-turbine selection needed for the evaluation of the concept of pumped-storage in the Meuse. Only the Archimedean screw turns out to be appropriate to achieve the main goal of the study as the screw shows near-zero fish mortality.

Reviewer B:

The changes in the paper are clearly visible, but the following still needs to be addressed:

- The abstract must be rewritten. The central theme does not get clear and the abstract is not well organized. The novel aspects are not clear.

See above. Abstract, introduction and conclusions have been clarified and partly rewritten. Main goal/ novelty is explicitly mentioned.

- The chapters must be reorganized. The chapters exist twice in method and results and it is not clear why.

- Chapter 2 and chapter 3 haven been combined to avoid any confusion. So there is only one chapter 2 ‘Methodology and results’. This chapter starts with a brief overview of the methodological steps 1, 2, 3, 4 and 5. Then these methodological steps are elaborated on in separate subparagraphs which also directly show the results.

- The methodology chapter must be improved and the method must be explained better. Explain the pump-turbine selection more detailed.

Methodological steps are broader explained in the introduction of chapter 2. In the subparagraphs more information on the results is provided. The subparagraph on pump-turbine selection has been extended to explain the pump-turbine selection more detailed.

- Discussion and conclusion must be written more consistent and efficient.

Discussion has been shortened and written more consistent. Only major considerations are mentioned. Conclusion has been rewritten clearly mentioning the main goal and the results of the study related to this main goal making it more consistent and concise. Side information is deleted in the conclusion.

- *The novelty of the study is not clear and must be pointed out.*

Novelty is mentioned in the abstract and introduction: the evaluation of the concept of using

canalized river sections for pumped-storage purposes within conditions of fluctuating discharge and - water levels throughout the year. Novelty is also mentioned in the conclusion.

- *The quality of the figures must be improved. Especially figure 1, 3, 4.*

Fig 1, 3 and 4 are improved/created in Photoshop instead of Paint. Resolution is much higher now, about X4. Fig 3, 7 and 9 are created using more dots per inch. So the quality of these images and the resolution has been improved.

Additional changes

- The version of May 25th is describing ‘power stored by the river’. This means: when blocking the flow at storage mode de river will start to fill the upstream sections leading to a minor storage of hydropower. As this was considered confusing information on this is removed from the article. Therefore, Fig 7 and Fig do not show a power graph ‘Power stored by the river’ anymore.

- JCHS guidelines on referencing are followed to make it consistent. So quotation marks like “RWS Waterinfo” are removed. For instance, in the article it is clearly mentioned the info in provided by a website of Rijkswaterstaat (RWS).

- When possible a more academic source was used to replace the information from a website, like for instance at “Stuwen Maas Sambeek” of the May 25 version. Originally, this source provided the information the Sambeek weir consist of Poiree- and Stoney weirs. However, this information was also provided in the thesis of Frijns (2019) so that source was used as replacement.