

After the RISEnergy Transnational Access, Users are required to submit a User Report. This should be done within 4 weeks after the Access is completed unless otherwise agreed. The User Report will be given to the User(s) by the WP2 leader. The report contains sections related to the work performed, the main results and observations that were achieved.

This document should be completed, signed, and sent by e-mail to risenergy@for.kit.edu.

Summary questionnaire for Users who have been granted Transnational Access (TA) under the RISEnergy project Horizon Europe TA scheme. More information on RISEnergy TA can be found in "General Rules" and in "Access Policy" which can be found on the RISEnergy webpage.

Please complete, sign, and send this form, together with the Cost claim by e-mail to risenergy@for.kit.edu with title: RISEnergy APPXXX - reports.

General information about the project	
Project title (as used in Application)	Advanced Crossflow Turbine with Integrated Onboard Storage
Project number (APPXXX) and acronym (max 15 characters)	APP 166 ACTIONS
RISEnergy RI(s) accessed	TA23/CNR - Towing Tank "Umberto Pugliese"
Keywords (up to five, free text)	Ocean Energy, Tidal Energy, Crossflow turbine, Energy Storage, Controls
Arrival date (in town where RI is located)	
Departure date (from town where RI is located)	
Starting date of Access (first day at RI)	09/03/2026
Finishing date of Access (last day at RI)	01/04/2026
Number of days not using the RI (during the above period)	6

Reason for not using RI those days (describe)	Weekend days	
Number of days using the RI	24	
Number of Users granted Access (group size)	6	
Comments		
User		
User group leader or sole applicant (user group member 1)		
First name		
Last name		
Affiliation / Employer		
Country of Employer		
E-mail		
User travelling to RI?		
Comments		
User group member 2		
First name		
Last name		
Affiliation / Employer		
Country of Employer		
E-mail		
User travelling to RI?		
Comments		
User group member 3		
First name		
Last name		
Affiliation / Employer		

Country of Employer	
E-mail	
User travelling to RI?	
Comments	
User group member 4	
First name	
Last name	
Affiliation / Employer	
Country of Employer	
E-mail	
User travelling to RI?	
Comments	
User group member 5	
First name	
Last name	
Affiliation / Employer	
Country of Employer	
E-mail	
User travelling to RI?	
Comments	
User group member 6	
First name	
Last name	
Affiliation / Employer	
Country of Employer	
E-mail	
User travelling to RI?	
Comments	
Please insert more fields if your groups had more than four members.	

Access Summary Report - work performed and initial results

Brief description of the objectives of your project (up to 200 words)

ORPC sought to measure the power and efficiency for a novel low-solidity crossflow turbine, and to characterise the thrust and torque loads generated by the turbine. Additionally, we sought to characterise the effect of added energy storage on the DC bus of the electrical system on turbine dynamics, turbine performance, and output power utility.

The full-scale turbine was to be tested in the CNR towing tank, which replicates the operation conditions for ORPC's RivGen turbine. During the operational testing, the Tip Speed Ratio (TSR) of the turbine was to be controlled by the generator and the flow around the turbine, and the turbine performance be monitored for later comparison with analytical models. Testing was to be carried out as per a pre-determined test matrix to achieve the most effective use of testing facilities. Energy storage on the DC bus was to be evaluated to assess the ability to modulate torque pulsation from the turbine, and the ability to deliver a high quality, steady state energy supply to the user.

Activities performed (up to 600 words)

[Please summarise the work carried you (steps taken, instrumentation used, techniques employed, data sources consulted etc.)]

Delivery of test articles: ORPC provided a full-scale turbine and power train assembly.

Commissioning: The model was equipped with all necessary instrumentation to characterize its hydrodynamic and electrical behaviour before being translated under the carriage. Using the facility's earth-moving machines, cranes, and specialized sub-frames, the turbine was positioned for coupling, while staff and scuba divers finalized the underwater installation. Once the mounting phase was complete, a preliminary set of shakedown runs were performed to verify all electrical and instrumental connections, ensuring the system was ready for the full experimental matrix.

Operational trials and performance monitoring: The full-scale turbine was tested in the CNR towing tank, which replicates the operation conditions for ORPC's RivGen turbine. During the operational testing, the Tip Speed Ratio (TSR) of the turbine was controlled by the generator and the flow around the turbine, and the turbine performance was monitored and recorded for later comparison to analytical models. Testing was carried out as per a pre-determined test matrix to achieve the most effective use of testing facilities.

ORPC conducted 106 individual tow tank runs in this test program, of which 99 are deemed acceptable test runs, with a range of tow speeds from 1.0 m/s to 1.8 m/s (in increments of 0.1m/s),

and tip speed ratios between 2 through 3.8, (in increments of 0.2). Depending on towing speed, the data acquisition time lasted between 120 and 160 seconds per towing run. Most of the tests were carried out in the forward direction. Some reverse runs were conducted at varying TSRs at 1.2m/s to confirm bi-directionality performance.

Tests were performed according to standard procedures for hydrokinetic turbines (IEC TS 62600-200 standards, ITTC recommended procedures 7.5- 02-07-03.9). The full-scale device was equipped with rotor RPM, mechanical and electric torque and power transducers to characterize power output and PTO operation. Output signals were acquired as synchronised time-histories and stored for data post-processing and elaboration.

Each run was performed at a single setpoint of flow speed and TSR, with the goal of acquiring at least 60 seconds of stable operation. Many setpoints were repeated a number of times during the length of the test campaign in order to check for sensor drift and/or a deterioration in the driveline. All data for each run is contained in a single CSV file. Runs are bundled in folders labelled by the date they were run on in the format DDMMYYYY.

A total of 106 CSV files exist in the dataset, beginning on March 13th. The dataset includes runs that stopped early due to VFD faults or that had no power or strain measurements. These kinds of faults are indicated in the CSV filename.

Data processing involves ingesting the raw CSV files from their date-based directory, performing various operations as outlined below, and outputting them into a single directory as parquet files. Only the stable towing phase is saved. The date of the run is preserved in the filename.

The steady-state window is found automatically using a 2-rotation rolling average of the 'OutputPower (kW)'. The towing phase is then saved separately as a parquet file:

- The 2-rotation rolling average is calculated from the set RPM.
- Samples where the rolling mean exceeds 500W are flagged as generating.
- A 10-second safety margin is added at the start and subtracted at the end to avoid transient edges.

Decommissioning: At the conclusion of the investigation, an inverse procedure was employed to safely recover the turbine. The unit was raised for drainage and inspected for structural fatigue before being decoupled from the carriage using the overhead crane. Staff and divers coordinated the release of the additional frames, allowing the crane and forklift to transport the model back to dry storage.

Scientific results (up to 800 words)

[Summarise the (initial) outcomes of your study at the RI(s).]

Operational trials of the MHK turbine were performed by deploying the device in the CNR tank and towing it at required speed to reproduce operation over a range of current flow speed and loading conditions.

The initial data analysis indicates that performance data was successfully collected for multiple operating points of the turbine. A map of tip speed ratio and turbine efficiency was established for

multiple flow speed conditions, and the maximum efficiency point was found to occur at a consistent tip speed ratio, as expected from theory.

Power increased as flow speed increased. Initial indications are that flow speed has an effect on turbine efficiency. The effect of having only two foils in the turbine was clearly evidenced by large variations in mechanical and electrical torque during a single rotation. Limits of electrical current were reached at the upper range of test flow speeds. Data analysed to date is consistent with expectations from computational fluid dynamics analyses.

Separate TSR sweeps were performed in both forward and reverse to check the bidirectionality of the test setup.

A number of setpoints were run multiple times to check for repeatability. The most repeated setpoint (1m/s at 2.8 TSR) demonstrated a coefficient of variation of 1.6%. This is considered a strong result, suggesting that this test campaign has a high degree of repeatability.

Strain data was successfully obtained as a function of turbine rotation. Of the eight strain sensors implemented, one of the sensors indicated an unexpectedly high level of strain throughout the test program. This may be related to a stress concentration at the strut/turbine junction or may be related to a defect in the build of the foil. Post test inspection of the turbine at this junction did not reveal any visible issue at this location.

The collection of strain data utilizing the same data acquisition system as other system parameters is a major success of the test program, allowing for validation of fluid structure interaction analyses for the turbine.

An extensive data set has been collected, and initial processing has been completed. However there remains a significant amount of work to be done to fully assess the test results, and the impact of the test program.

At this stage ORPC can confirm that the novel turbine is more efficient and more powerful than the baseline system.

Interpretation of the results (up to 400 words)

[Discuss the data obtained and describe the major scientific conclusions drawn.]

Performance data for the turbine has been obtained across a wide range of operating parameters. A map of tip speed ratio and turbine efficiency was established for multiple flow speed conditions, and the maximum efficiency point was found to occur at a consistent tip speed ratio, as expected from theory.

The effect of having two foils in the turbine was clearly evidenced by large variations in torque during a single rotation. Limits of electrical current were reached at the upper range of test flow speeds. Data analysed to date is consistent with expectations from computational fluid dynamics analyses.

Strain data was successfully obtained as a function of turbine rotation. Of the eight strain sensors implemented, one of the sensors indicated an unexpectedly high level of strain throughout the

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Main achievements during the TA related work (up to 250 words)

[Describe the main achievements during your stay at the site(s), Outputs (results, publications, models, etc.), conclusions, next steps, potential impact]

The successful completion of testing of a novel hydrokinetic system involved many separate steps, each of which was necessary, including:

- 1) Construction and shipment of the system
- 2) Installation of the system
- 3) Commissioning of the system
- 4) Collection of hydrodynamic performance data
- 5) Collection of strain and structural data
- 6) Decommissioning of the system

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At this stage ORPC can confirm that the novel turbine is more efficient and more powerful than the baseline system.

Data Management

[Describe the further usage and storage of project data. State where the data will be kept and name a person responsible for the data. Define data]

The project generated design and testing datasets, accompanied by several technical reports.

Tests were performed according to standard procedures for hydrokinetic turbines (IEC TS 62600-200 standards, ITTC recommended procedures 7.5- 02-07-03.9). The full-scale device was equipped with rotor RPM, mechanical and electric torque and power transducers to characterize power output and PTO operation. Output signals were acquired as synchronised time-histories and stored for data post-processing and elaboration. This data was collected and stored at high frequency and results in several hundred Gbytes of raw data. The raw data has been stored by ORPC in multiple locations, and processing of the data is underway to compress data to a more compact form. ORPC will maintain the full set of data on its cloud storage system after the close of the project.

Data exploitation will be done in line with IP Management rules to ensure the secure and responsible management of user and hosting facility IP rights and ownership, in accordance with Open Science and FAIR data principles.

Mr. Patrick Cronin of ORPC, Ireland is the person designated as being responsible for the data.

Difficulties during the TA related work (up to 250 words)

[List problems and issues, you had, completing out your research project: Did you get access to all the necessary equipment, facilities, databases, etc.? If not, please specify the problems that occurred and list equipment that was not working or accessible.]

With any complex project there will inevitably be issues consolidating all the efforts between multiple parties. Some of the issues encountered included:

- Access dates for the facility required multiple trips to the facility to allow for assembly of shipped equipment and commissioning of the system.
- Communication between the user and the facility would have benefited by a pre-trip visit by the user to the facility prior to the access date

Data collection efforts were impacted by several factors including:

- Load cells were not available at the facility in sufficient time for inclusion on the test rig
- Voltage and current sensors ordered by ORPC proved to be not fit for purpose, and re-ordering of these sensors meant that high frequency current and voltage data was available for only the later part of the test regime
- High frequency voltage data was corrupted by EMF interference
- Many of these data acquisition and sensor issues would have been more successfully addressed if a period of pre-access time was built into the facility access agreement to allow for integration and testing of sensor and data acquisition components. This would need to be in the order of one month of time ahead of testing for such a complex test program

Testing of energy storage was not conducted due to insufficient facility access time

Intended publications

[Explain where and how you expect to publish the outcomes of your project work. Include also anything already published (What and where?)]

Data collected under this project will be commercially sensitive, however ORPC expects to disseminate data related to performance of the turbine using non-dimensional performance metrics, e.g. non-dimensionalised turbine torque as a function of rotational position, under constant speed control, with and without energy storage. These data will be shared via an open scientific data repository such as SEANOE, as was done during the CRIMSON project. The outcomes from the project will also be disseminated publicly through peer reviewed technical conferences and to non-technical audiences through:

- Conference paper/presentation at the International Conference on Ocean Energy 2026
- Inclusion in other presentations at international industry conferences, e.g. Ocean Energy Europe Conference 2025, MRIA Ireland Forum 2026
- Social media posts and videos describing the testing, following the experience of the ACTIONS Project.

The proposed test facility will have access to the data sets and will be able to use these to inform data processing techniques to assess performance of marine energy systems, including those with embedded energy storage. The test facility is expecting to participate in the maintenance and development of international test standards through the International Electrotechnical Commission (IEC TC114) standards development program.

Expected impact

[The impact the expected results will have on current and future research or practice, public safety, European standardization, competitiveness, integration and cohesion and on sustainable growth. any follow on proposals, projects, collaborations, commercialisation]

A novel turbine design was tested. This turbine features fewer foils than prior ORPC turbines. The design consists of a two-foil crossflow turbine, where each foil is helically twisted. The reduced solidity achieved by a reduction in the number of foils from 3 to 2, is expected to increase the rotational speed and efficiency of the turbine and reduce cost. However, the reduction in number of foils leads to an increase in the torque variation during the rotation of the turbine. Increased torque variation will lead to variations in rotational speed within a single rotation, pulsation in mechanical torque, and consequent pulsation in electrical current. The torque pulsations may also lead to changes in the instantaneous rotation rate of the turbine and changes in local hydrodynamic angle and a consequent change in turbine efficiency.

This design has been advanced through detailed numerical modelling studies and with inputs from small-scale laboratory tests. Lower solidity for a crossflow turbine was expected to increase turbine efficiency and power output. Less material usage was to contribute to a lower capital cost

for the system. The tested crossflow turbine is innovative in the use of control co-design for optimization of turbine performance and structural interaction.

In testing ORPC has obtained an efficiency map for the turbine as a function of the non-dimensional rotational rate (tip speed ratio).

These measurements will validate the turbine design, and its suitability for use in field deployments. Test data will contribute to an understanding of crossflow turbine performance and the effect of solidity on performance, variations in thrust and torque loading due to a reduction in number of blades.

The proposed work aligns with the priority topic *Innovative PTO and control systems* in the Strategic Research and Innovation Agenda (SRIA) for Ocean Energy published by ETIP Ocean in October 2024. Key impacts will include improved power and operative performance of the turbine, including its conversion efficiency; improved knowledge of the critical failure modes and survivability of the system; and improved cost and performance projections.

The work will deliver credible performance projections, which are a basis for obtaining private and government funding for continued development of commercial systems using this novel turbine.

Conclusions / additional comments

[Provide any other comments you might have on your work]

Working with CNR staff is an excellent experience and provided wonderful training and exposure for ORPC engineers.

Did you complete the European Commission User questionnaire
<https://ec.europa.eu/eusurvey/runner/RIsurveyUSERS?>

Yes No

Feedback - HSE, Ethics and Satisfaction

Please rate on a scale from 1 (excellent) to 5 (poor). Feel free to provide additional comments

Practical information on how to apply for Transnational Access and the overall application process

1 (excellent)	2	3 (neutral)	4	5 (poor)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	X	<input type="checkbox"/>

Comment

Information provided, once your project was accepted, on how to proceed	<table border="1"> <thead> <tr> <th>1 (excellent)</th> <th>2</th> <th>3 (neutral)</th> <th>4</th> <th>5 (poor)</th> </tr> </thead> <tbody> <tr> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td><input type="checkbox"/></td> <td>X</td> <td><input type="checkbox"/></td> </tr> </tbody> </table>	1 (excellent)	2	3 (neutral)	4	5 (poor)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	X	<input type="checkbox"/>
1 (excellent)	2	3 (neutral)	4	5 (poor)							
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	X	<input type="checkbox"/>							
<p><i>Comment</i></p> <p>Communication mechanisms with the funding organization could be improved.</p>											
Support received at the site(s) regarding technical/scientific matters and logistics	<p>Have you got sufficient support from the RI staff during the project? If not, please, specify the problems. X <input type="checkbox"/> Yes <input type="checkbox"/> No</p>										
<p><i>Please specify any problems</i></p>											
RI extension / upgrades required	<p>In your opinion, is the RI needed to be upgraded? If yes, please give an explanation. <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p>										
<p><i>Please specify</i></p>											
Problems with local regulations	<p>Have you had any problems with regulations of the visited RI owner (HSE, lab working hours, etc.)? If yes, please, specify <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p>										
<p><i>Please specify</i></p>											
Health and safety issues	<p>Did you encounter any health or safety issue during your research? Please provide details. <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p>										
<p><i>Please provide details</i></p>											
Environment & Ethics	<p>Did your research involve the use of elements that may cause harm to the environment, to animals or plants? Please provide details. <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p>										
<p><i>Please provide details</i></p>											
Environment & Ethics	<p>Did your research deal with endangered fauna and/or flora and/or protected areas? Please provide details. <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p>										
<p><i>Please provide details</i></p>											
Environment & Ethics	<p>Did your research involve the use of elements that may cause harm to humans, including research staff? Please provide details.</p>										

	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No					
<i>Please provide details</i>						
Environment & Ethics - Dual use	Does your research have the potential for military applications? Please provide details. <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No					
<i>Please provide details</i>						
Environment & Ethics - Misuse	Does your research have the potential for malevolent /criminal/terrorist abuse? Please provide details. <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No					
<i>Please provide details</i>						
Environmental issues	Were any potentially dangerous substances (materials / gases etc.) released into the environment (atmosphere, water, or land)? Please provide details. <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No					
<i>Please provide details</i>						
Ethics issues	Are there any other ethics issues that should be taken into consideration? Please specify <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No					
<i>Please provide details</i>						
Overall impression of communication and interaction after finishing your TA and related work	1 (excellent)	2	3 (neutral)	4	5 (poor)	
	X <input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Comment Communication with the RI was excellent Communication mechanisms with the funding organization could be improved.						
Suggestions for facilities not included in RISEnergy which you would use for your research						
[Please provide suggestions for specific type of facilities missing (RI gaps) or measurement / experiments you would like to perform which can not be done on current RISEnergy facilities.] None						
Suggestions how RISEnergy can improve future TA programme, how to make the TA more impactful and how to enable the achievement of high TRL levels						

[Your suggestions]

I would suggest that the funding organization have a kick-off meeting with the user when the award is made. Also, I would suggest that the funding organization nominate and identify a point of contact at the funder with which the User can communicate.

Feedback - Pro-active Innovation Support

Awareness

Did you know about the pro-active innovation support of RISEnergy?

Yes No

[Please specify how you learned about the pro-active innovation support]

Personal experience

Have you taken advantage of or benefited from the pro-active innovation support?

Yes No

[Please provide details]

Information/service provided by the pro-active innovation support?

1 (excellent)	2	3 (neutral)	4	5 (poor)
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

[Please provide details]

I declare that the above provided information and especially that information on the number of days visited the RI is correct.

I have read the [RISEnergy privacy policy](#) for participation in the RISEnergy TA and consent to participation and the associated data processing.

Your full name:

Your signature: