HYBRIDIZATION OF A ROR HPP WITH A BESS – THE XFLEX HYDRO VOGELGRUN DEMONSTRATOR

S. Kadam[1], W. Hofbauer[1], S. Lais[2], M. Neuhauser, E. Wurm[1], L. Fernandes Lameiro[1], Y.M. Bourien[3], G. Païs[3], J.L. Drommi[4], C. Nicolet[5], C. Landry[5], M. Dreyer[5], Carme Valero[6], A. Presas[6], D. Valentin[6]

Abstract: In the XFLEX HYDRO Demonstrator Vogelgrun, a run-of-river hydro power plant, the hybridization of one turbine-generator unit with a battery energy storage system is being investigated. This paper describes the integration methodology of the hybrid control algorithm without replacing the existing speed-governor of the unit. Furthermore, the comparison of the performances of a non-hybrid and hybrid unit is discussed, and first experiences gained during the operation and monitoring of the hybrid operating mode are presented.

1 Introduction

With the phase-out of thermal power plants and integration of intermittent renewables such as wind and PV, the demand for operational flexibility in power systems changes and increases. Therefore, the capability of existing hydro power plants to offer such flexibilities is becoming even more important. In [1], the contribution of hydropower to grid resilience is described. To increase the operational flexibility of hydro power plants (HPP) further, existing limitations, which are defined by the HPP type (e.g. run-of river, pumped-storage hydro, reservoir type etc.), have to be overcomed by means of technological improvements. At the same time, other regulations (e.g. water framework directive) have to be respected at all times.
In the Horizon 2020 funded XFLEX HYDRO project ([2]), a consortium of 19 partners demonstrates for different types of HPPs, how more flexibility can be provided to enable the integration of even more intermittent renewables. In total, innovations are demonstrated at seven HPP locations in Portugal, France and Switzerland. Demonstrated technologies are a conversion to variable speed, hydraulic short circuit and a battery hybrid system.
In the XFLEX HYDRO Vogelgrun demonstrator, a run-of-river power plant, Frequency Containment Reserve (FCR) is provided with a battery hybrid.

[1] ANDRITZ HYDRO GmbH
[2] ANDRITZ HYDRO AG
[3] CEA
[4] EDF
[5] PVE
[6] UPC

To provide FCR, the contracted grid service has to be provided for a full activation (200 mHz) within 30 seconds ([3], [4]). The optimization and sizing for stand-alone battery energy storage system (BESS) were discussed in [5]–[7]. In [5], to provide 1 MW of FCR with a stand-alone BESS, a minimum BESS size of 1.6 MW/1.6MWh was proposed.
The paper is organized as follows. In section 1, the demonstrator is explained in detail. In section 2, the control strategy, monitoring concept and methodology of benchmarking the benefits of the hybridization are described. In section 3, field results of the demonstrator are presented. A conclusion and outlook is given in section 4.

1. Description of the XFLEX HYDRO Vogelgrun demonstrator

In this section, the XFLEX HYDRO demonstrator Vogelgrun is described.
In the run of river HPP Vogelgrun (RoR), four Kaplan units with a nominal power of 35 MW are installed. At this demonstrator, the hybridization of one turbine-generator-unit (TG-unit) with a battery energy storage system (BESS) of 650kW/370kWh is tested. The technical and economical constraints in the optimization of the BESS size were described in [8]. The target of the demonstrator is to improve FCR provision and dynamics with a hybrid system, increase the flexibility capability and at the same time reduce wear and tear compared to a non-hybrid TG-unit by 90%. Furthermore, a minimal sized BESS shall be used. The four TG-units provide 4 MW of FCR each. Also, the existing speed-governor of the hybridized TG-unit, shall not be replaced.
In the case of Vogelgrun demonstrator, the response time of 30 seconds for FCR provision is met thanks to a hybrid controller and a dedicated algorithm, splitting the active power setpoint to the BESS and the TG-unit., which has a slower response.
For all demonstrators in the project, an aggregated ancillary services matrix was developed. Within this ancillary service matrix, the performance of each demonstrated technology for different grid services was evaluated ([9]).

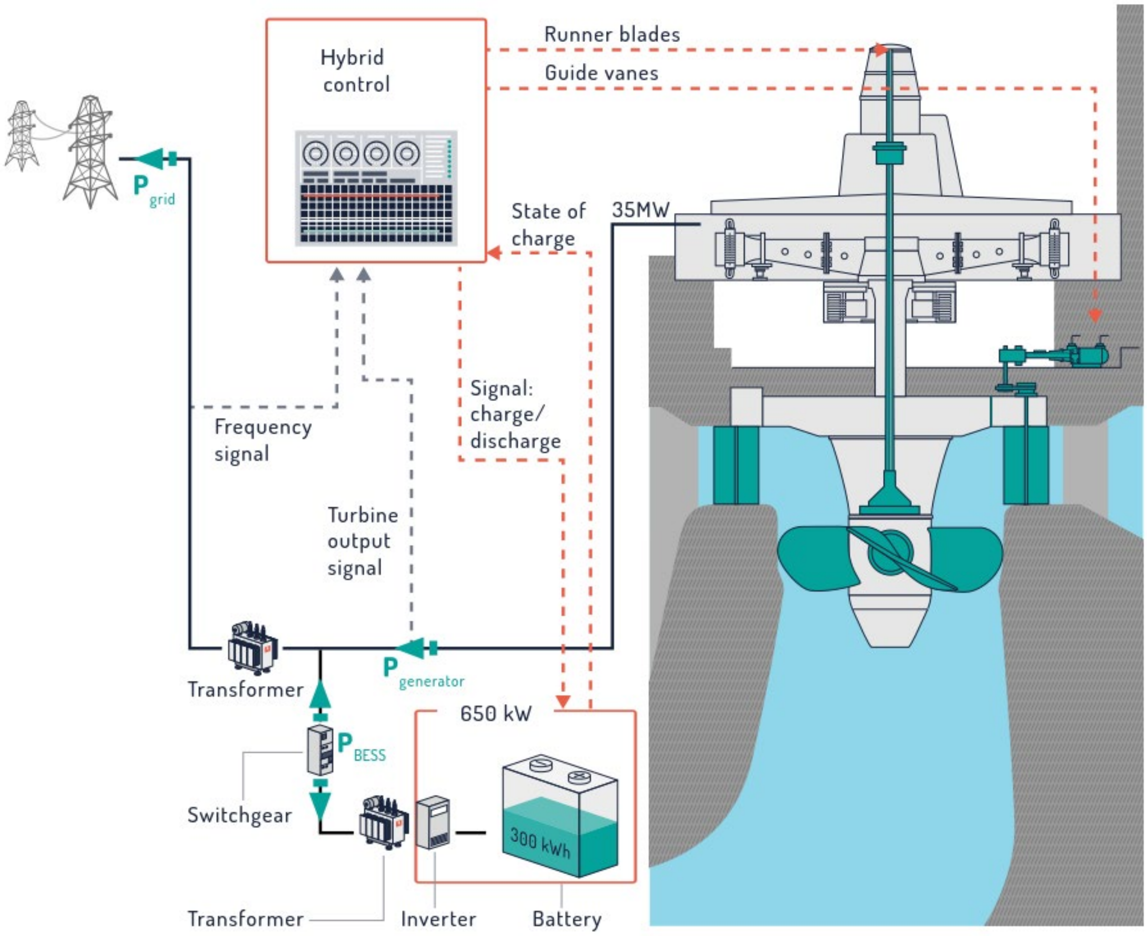

Figure 1: Overview of the hybrid unit setup

2. Methodology

In this section, the control strategy of the hybrid system is described. Further, the monitoring concept, wear and tear assessment as well as developed real-time simulation models are explained.

2.1. Control strategy

In this section, the control strategy of the hybridized unit is described.
Vogelgrun hybrid demonstrator is driven by FCR dynamic response and by wear and tear reduction. These two goals led to the hybridization algorithm, and it consists of controlling HPP and BESS power simultaneously. Indeed, at every moment the sum of these two powers on the grid, has to be equal to the power expected by the TSO regarding the frequency deviation.
The diagram in Figure 2, presents the control overview where grid frequency and BESS state of charge (SoC) signals are the inputs of the algorithm and where BESS power and HPP frequency set points are the outputs of the controller. In general, the HPP's controller uses the frequency signal to modulate its power generation regarding frequency deviation. The aim of the hybridization algorithm is to control the HPP's power through its actual governor thus utilizing existing hardware. For this purpose, the hybrid controller recreates an analogic frequency signal to control the existing turbine governor. Computation steps of this algorithm are explained there:

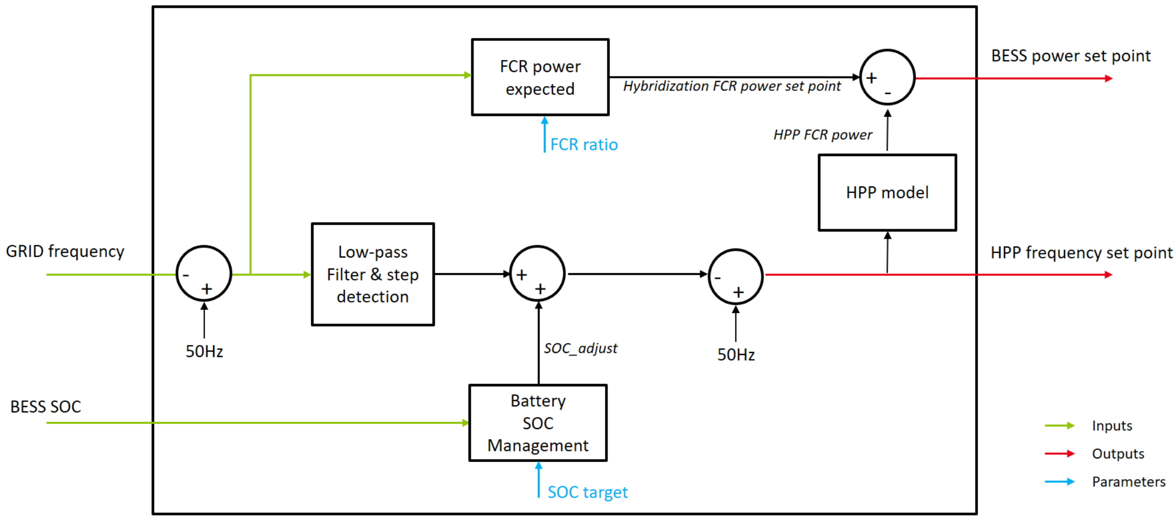

Figure 2: Control algorithm overview

HPP control is based on filtered grid frequency modulated with SoC-Management. The first bloc named “Low-pass Filter & step detection” is a first order low pass filter and creates the “smooth version” of the grid frequency signal. The time constant of this filter is set to 30s (modified to 100s) and was chosen to optimize wear and tear and FCR coverage. Moreover, a step detection process is also computed in this block and comparing the temporal variation of the frequency to a threshold. Abrupt variations of the frequency are detected and the magnitude of filtered signal is boosted by a gain of 1.2 to speed up power time response of the HPP. Finally, the filtered signal is updated by the signal provided by the block named “battery SOC management”. Indeed, the DC power profile applied to the battery is not symmetrical in terms of energy, efficiency is not of 100% and the BESS reaches quickly lower

values of SOC. Battery SOC management block addresses this behaviour and operates the BESS around a SOC target. The strategy is to modulate energy provided by HPP to charge or discharge batteries to maintain the BESS SOC target level.
When the operating SOC does not reach the SOC target parameter the signal “SOC_adjust” deviates the frequency set point of HPP according to the look up table presented on Figure 3. Thereby the input is the delta SOC, computed as the difference between battery’s SOC and a constant parameter SOC_{target} (fixed to 0.6 in order to limit battery ageing). Therefore when SOC is in the range from 40% to 80% (respectively delta SOC in range [-0.2 0.2]) “SOC adjust signal” remains close to 0 and no extra or under power from HPP is used to manage BESS energy stock. But when SOC is in the range from 10% to 40% (respectively delta SOC in range [-0.5 -0.2]) linear correction is used and frequency signal sent to HPP is decreased. Accordingly, HPP power increases and the overproduction is used to charge batteries. The frequency adjustment signal is saturated to +/-32.5 mHz and corresponds to the maximum BESS power (650kVA). In the same manner as presented previously, when SOC is in range from 80% to 85% (respectively delta SOC in range [0.2 0.25]) linear correction is used and frequency signal sent to HPP is increased. As a result, the HPP’s power decreases and BESS is discharged to provide more energy to the grid.

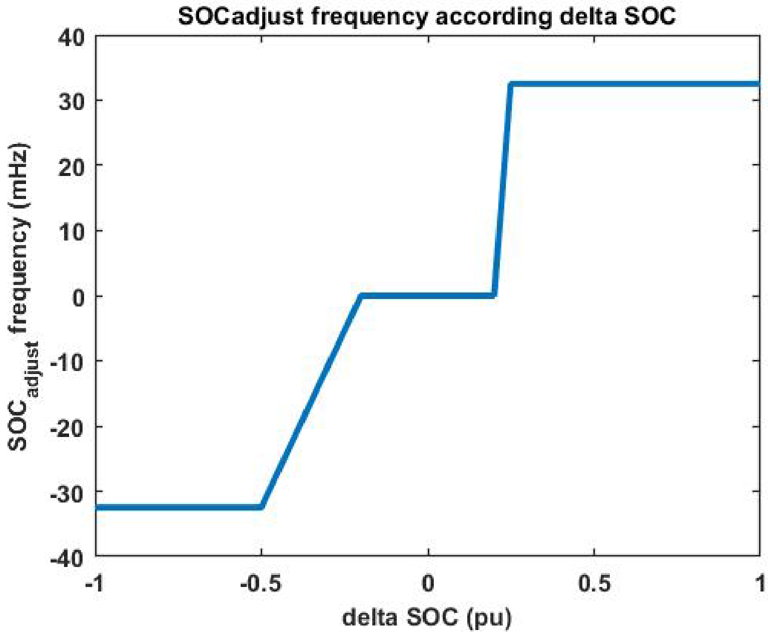

Figure 3: Frequency adjustment algorithm

BESS power set point is the difference between power required by FCR response (“Hybridization FCR power setpoint”) and the power provided by the HPP controlled with frequency signal from hybrid controller. Regulating power “Hybridization FCR power setpoint” is computed as the frequency deviation from 50Hz multiplied by a ratio “FCR ratio” fixed to 20MW/Hz. Unfortunately, the power provided by the HPP controlled with frequency signal from hybrid controller is physically unmeasurable. This signal is estimated by the “HPP model” block from the HPP frequency set point, and it corresponds to a first order model with a time constant measured on the TG-unit.

Considering the rules of SOC management bloc described previously, Figure 4 presents the behavior of the controller regarding the SOC (blue curve in the middle plot) during a frequency deviation (red curve in top plot). In case of under frequency (<50 Hz), the battery is discharged and SOC signal decreases (from time 250s to 580s). After time 300s, SOC is lower than 40% and SOC management strategy influence is visible with the difference between HPP frequency signal set point with adjustment (green curve in top plot) and without adjustment (output filter signal, purple curve in top plot). After time 580s, BESS's output power (pink curve in bottom plot) becomes negative and the BESS is charged with increased HPP output power (green curve in bottom plot).

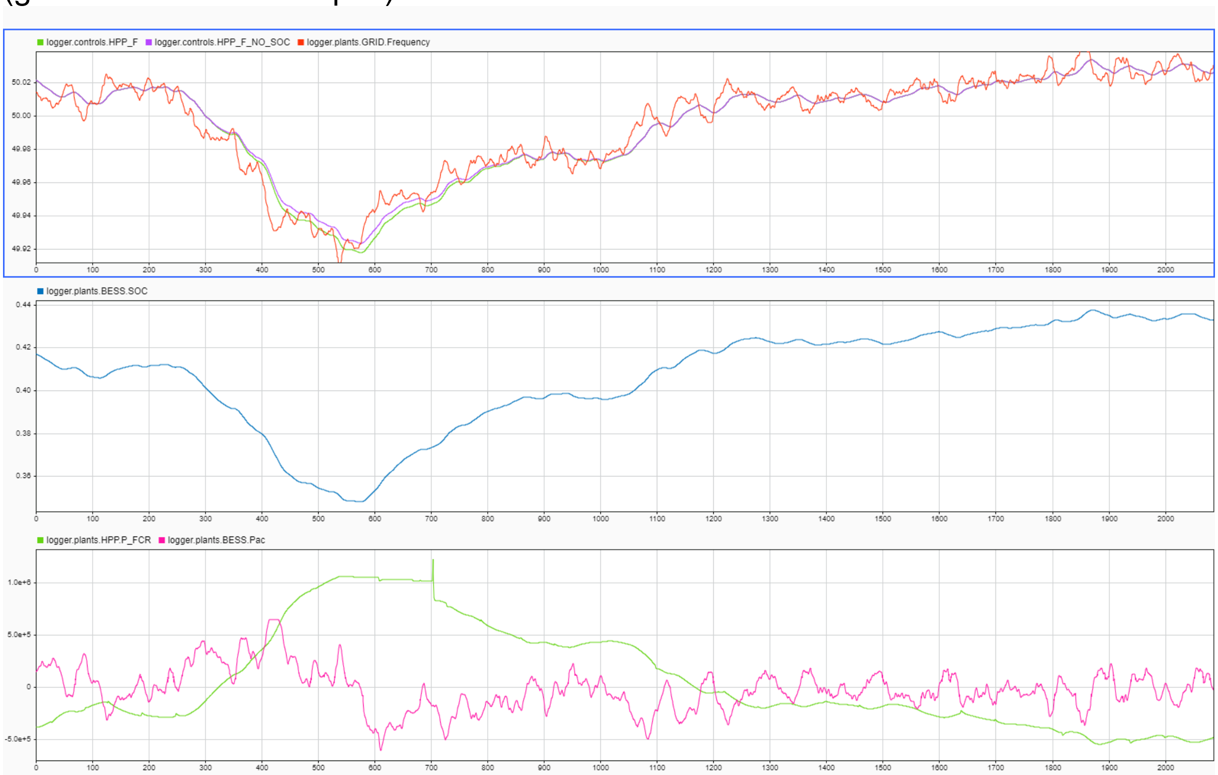

Figure 4: Simulation of BESS operation with SOC management implementation

Additionally, an ageing campaign on testing bench with climatic chamber regulated at 25°C on representative lithium-ion C/NMC cells of the ones used in Vogelgrun demonstrator was carried out. Power profile is made of 2 phases and it has been tested in February 2020. The ageing phase consists of applying 3 weeks the current profile based on February 2018 FCR power profile followed by a check-up test phase to control cell's capacity. The initial state of health (SoH) is not at 100% as experimental cells faced calendar ageing prior to the ageing campaign. Figure 5 shows the comparison between experimental (in red) and model prognostic results (in blue). This comparison highlights model prognostic and is very close to experimental results and SoH error remains below 1% after 1200 equivalent cycles, defined as total energy throughput divided by 2 times the nominal energy.

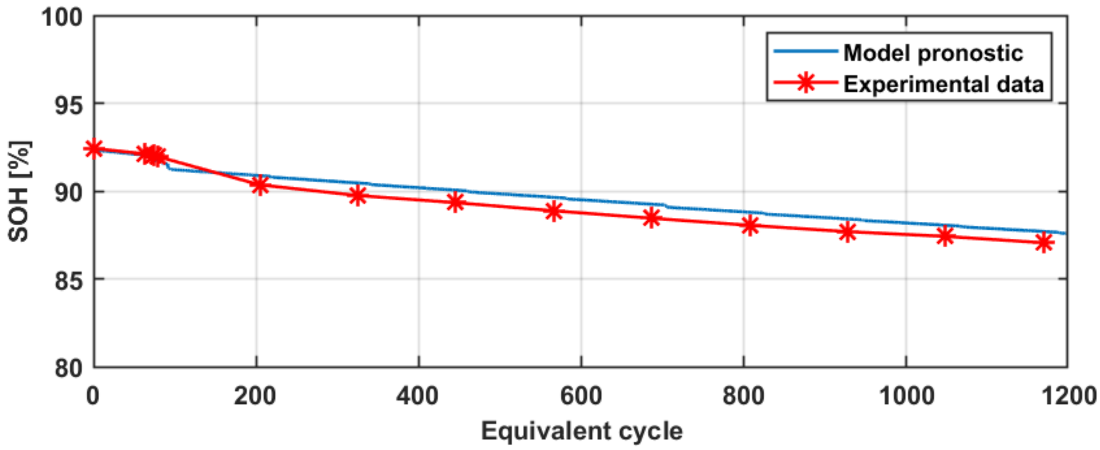

Figure 5: Experimental results vs model prognostic comparison

2.2. Monitoring concept

In this section, the monitoring concept deployed at the power plant is described. In Figure 6, the overall monitoring concept is depicted. There are four systems deployed, which are either via Modbus TCP/IP or analogue signals (Voltage signals) connected to each other. The blue circle marks the HIPASE hybrid controller system, the BESS and the SCADA monitoring system running on an industry PC. Due to security reasons, there is no access of the hybrid controller via VPN. To exchange signals to the MVX monitoring systems, analogue signals are used. From the MVX, the collected measurement signals from unit 1 and unit 3 as well as selected signals from the hybrid system are distributed to the Hydro-Clone and DiOMera. Each of these three systems are remotely accessible.

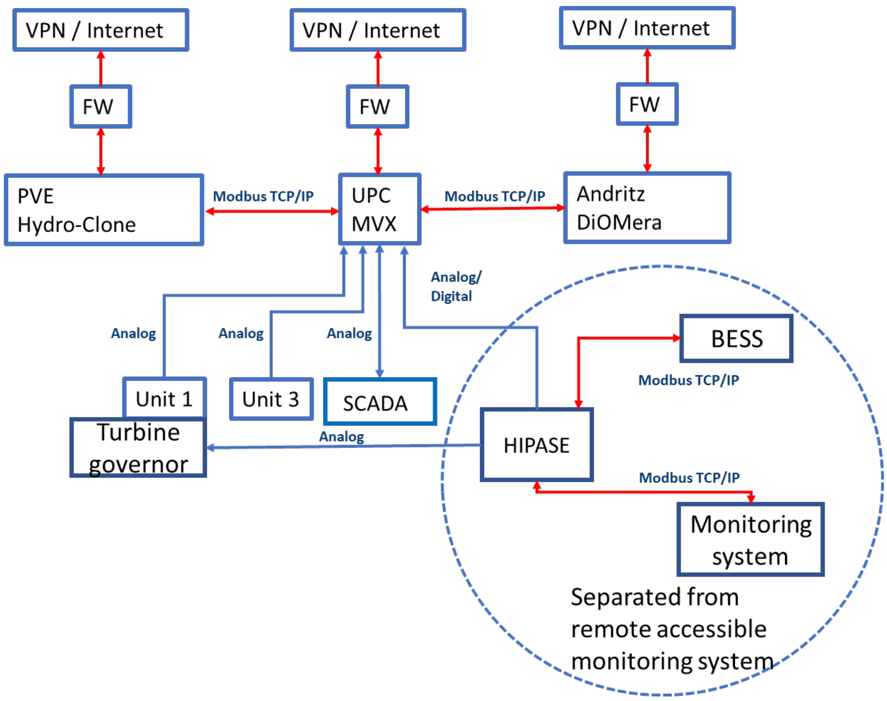

Figure 6: Overview of monitoring concept

2.3. Wear and tear assessment

In this section, the wear and tear assessment is discussed.
The mainly affected mechanical components of a Kaplan turbine during primary regulation in the sense of wear and tear are the turbine runner and the guide vane mechanism. These parts were modelled in 3D and analyzed with finite element methods (FEM). The therefore needed hydraulic loads acting on runner blade and guide vane were obtained from separate computational fluid dynamics (CFD) simulations (Figure 7). The damaging impact during FCR in the sense of fatigue are the frequent adjustments of the runner blade and guide vane angular positions. At each adjustment cycle, moving blades and vanes back and forth friction must be overcomed, leading to certain stress amplitudes at the parts. Wear depending on the turning distance of the trunnions in the bearings and the bearing load is calculated with the pressure distributions gained from the finite element analyses (Figure 8). The FE-models are simplified using cyclic symmetry but containing the full mechanism.

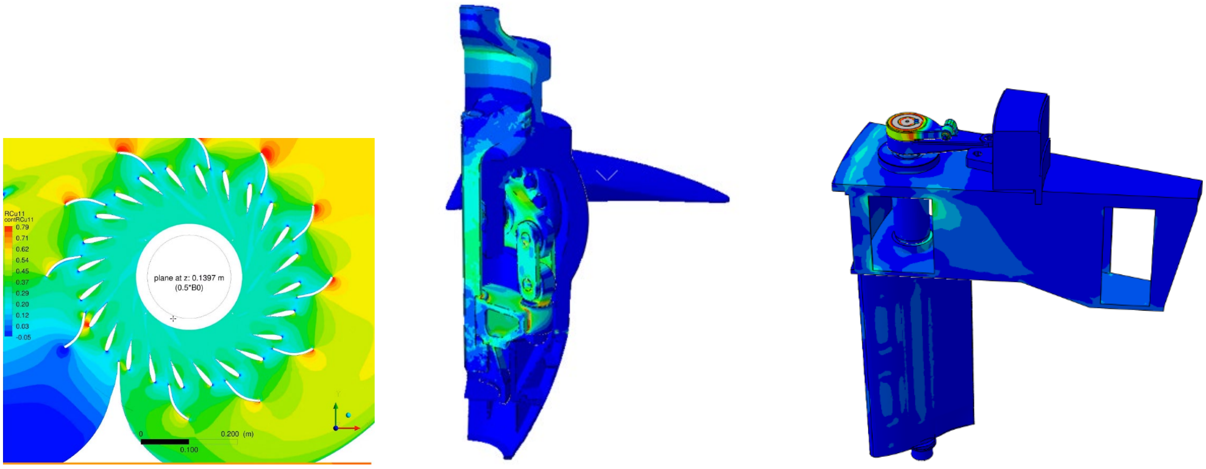

Figure 7: Flow condition at the guide vanes (left); Stress amplitude results at runner and guide vane mechanism finite element model (middle and right)

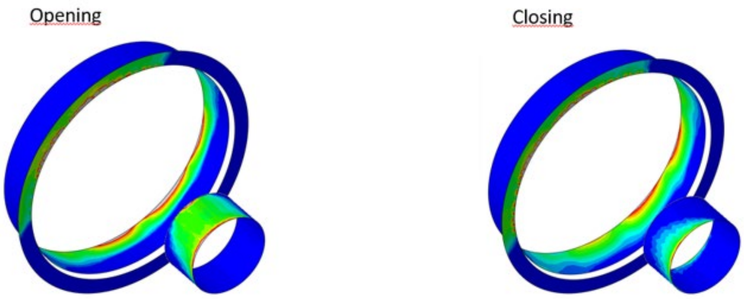

Figure 8: Contact pressure distribution at runner blade bearings

Hillcharts for wear (bearing deterioration) and fatigue (utilization of the turbine parts) should describe the damage in each point of operation – for the runner and the guide vane mechanism. In Figure 9,**Error! Reference source not found.** the utilization for approximately one year of primary regulation is presented. The link pin at the runner is the most endangered part for failure. With the fatigue hillchart points, the operation with high and low utilization can be detected.

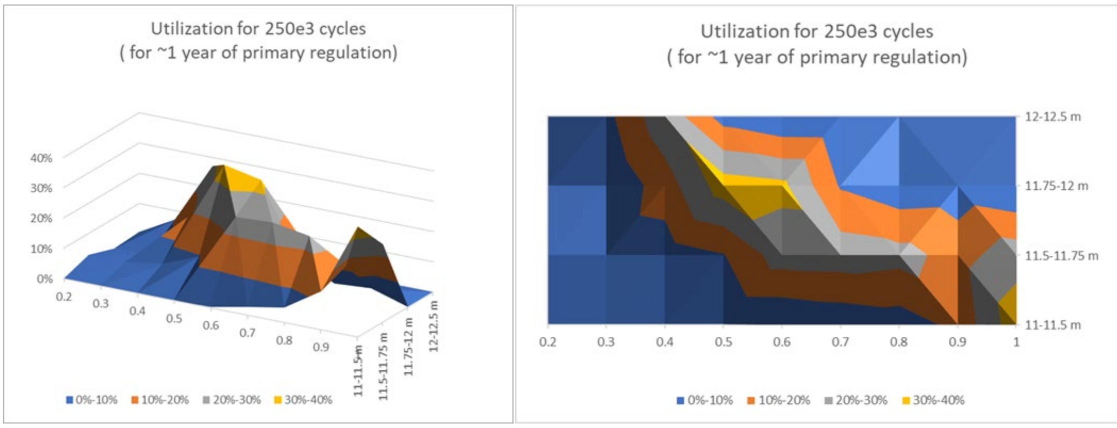

Figure 9: Utilization for approximately 1 year of primary regulation

Metris DiOMera, the digital solution of predictive maintenance of Andritz Hydro, was installed in Vogelgrun on a computer in the powerhouse. In Metris DiOMera Health and Trend Indicators are defined, that describe the current state of a component or group of components of the units and that predict its future behaviour. It is distinguished between so-called Key Diagnosis Indicators (KDI) that evaluate the past and present condition of a component and Key Trend Indicators (KTI) that predict future evolution of the KDIs. KDIs are normalized, where 0% means good condition and 100% means critical condition. For Vogelgrun, the main emphasis is put on KDIs that analyze wear and tear of the turbine with the aim of quantifying the improvement of the hybrid mode on the turbine aging. Wear of runner blade bearings and fatigue of the runner regulating mechanism were identified as the most relevant indicators.

Status of wear of runner blade bearings: Wear of the runner blade bearings depends on the distance that is covered by the movement of the runner blades (the so-called mileage), the contact pressure and a wear coefficient. The mileage is computed from the acquired runner servomotor position, the contact pressure comes from FEM and the wear coefficient is chosen according to literature. Wear in [mm] is converted in a non-dimensional KDI by defining a critical limit value for wear.

Status of fatigue of runner regulating mechanism: From the recorded servomotor opening and closing pressures a servomotor force is computed that is then converted into stress by applying FEM results. The number of load cycles is determined using rainflow counting. Using Miner's rule and an appropriate SN curve yields cumulated damage for the considered period. The same method can be applied to different parts of the runner regulating mechanism.

In order to compute these indicators based on real operation, operation data is acquired from the MVX monitoring system for unit 1 and unit 3. Thereby data of unit 3 serves as comparison to the hybrid unit 1.

Metris DiOMera comes with a web based graphical user interface (GUI) showing data visualization of all acquired and computed signals as well as the Health and Trend Indicators. In Figure 10 one tab of the GUI showing histograms of acquired active power of the turbine and head is depicted, as one example.

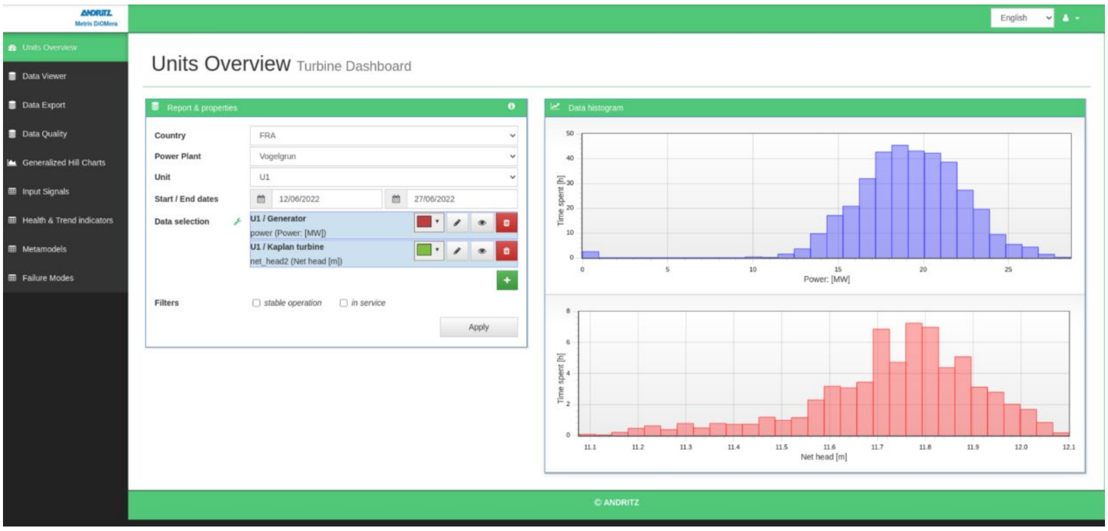

Figure 10: Screenshot of the graphical user interface of Metris DiOMera in Vogelgrun

2.4. Real-time simulation models

In this section, the developed real-time simulation models are described
A SIMSEN model of Vogelgrun HPP was developed including the water intake, the Kaplan turbine and the draft tube of the unit, see (Figure 11). A particular attention has been paid to the modeling of the spiral case in order to consider the evolution of the cross-section area and the distribution of the discharge. The hydraulic part of the numerical model was validated by comparing the simulation results with time series of static pressure in the spiral case and the rotational speed of the Kaplan turbine measured during an emergency shutdown performed in 2015 ([10]). The SIMSEN model also includes a turbine governor combining the control of the flow of the Rhine river and the FCR control. The turbine governor is operated in guide vane position control mode and uses on-cam look-up table to define the blade angle set point as function of the head and the guide vane position. The validation of the control part in the SIMSEN model was performed by comparing the numerical simulation results with the site measurements performed over 2 days in April 2021, see Figure 12. By using turbine flow set point and grid frequency time histories, it was possible to reproduce the time evolution of the active power, guide vane opening and blade angle with good agreement. Thus, the good reproduction of the active power *Pe* validated the characteristic curve of the Kaplan turbine. Moreover, the good agreement for the guide vane opening confirmed the turbine governor behavior. Finally, the on-cam curve was also attested with the comparison of the blade angle *beta*. This model was then used for real-time monitoring of the Vogelgrun HPP with Hydro-Clone.

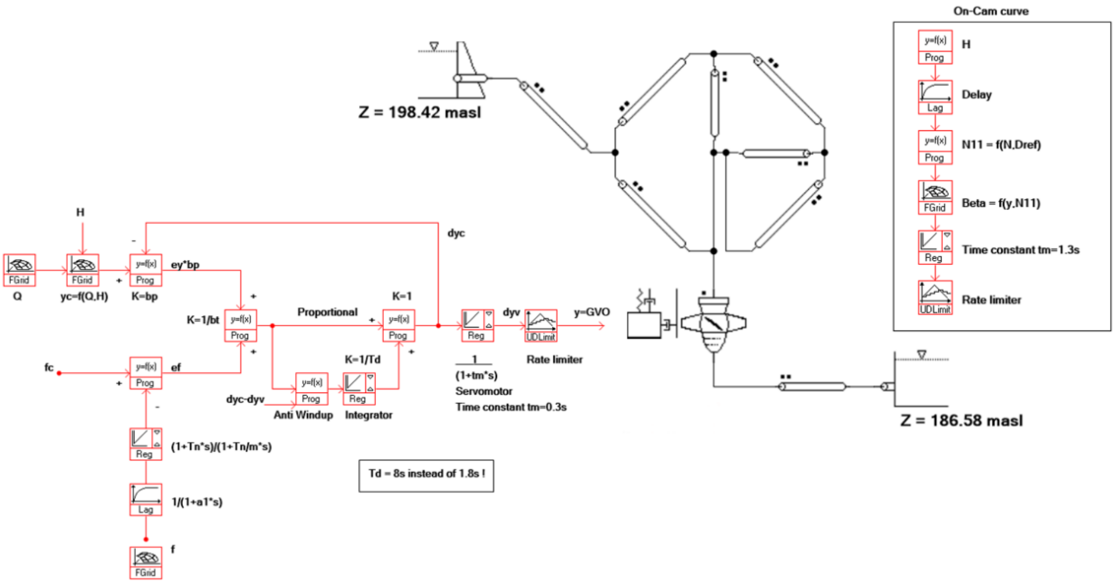

Figure 11 SIMSEN model of the Vogelgrun HPP

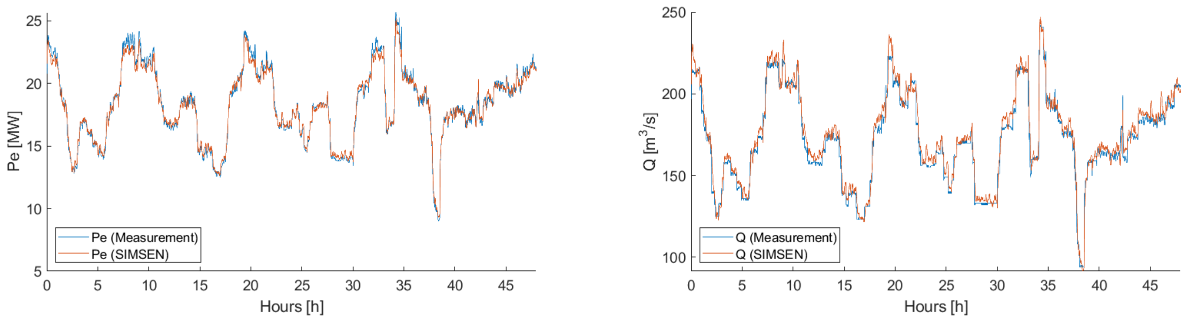

Figure 12 Comparison of power and discharge measurements (blue line) made over 2 days in April 2021 and numerical results (red line).

Hydro-Clone is an innovative Real-Time Simulation Monitoring System (RTSM) based on a well calibrated and validated SIMSEN model of the hydropower plant capable of reproducing in real-time any dynamic behavior of the plant based on the boundary conditions measured in situ, i.e. a digital twin ([11]–[13]). This system allows continuous diagnosis of the health of a hydro power plant by digital cloning of the main hydraulic and electrical components of the plant. The Hydro-Clone general concept is illustrated in Figure 13. The system manages the tasks of real-time acquisition and transfer of boundary conditions and measured quantities to the SIMSEN model, as well as data processing and diagnosis of the HPP health status. A custom-built archival storage system and an associated database allow for the display and analysis of previous results. The analysis and comparison of simulated and measured quantities enable to understand at any time the fitness and behavior of all essential components of the system and to estimate non-measured/non-measurable quantities throughout the whole system.

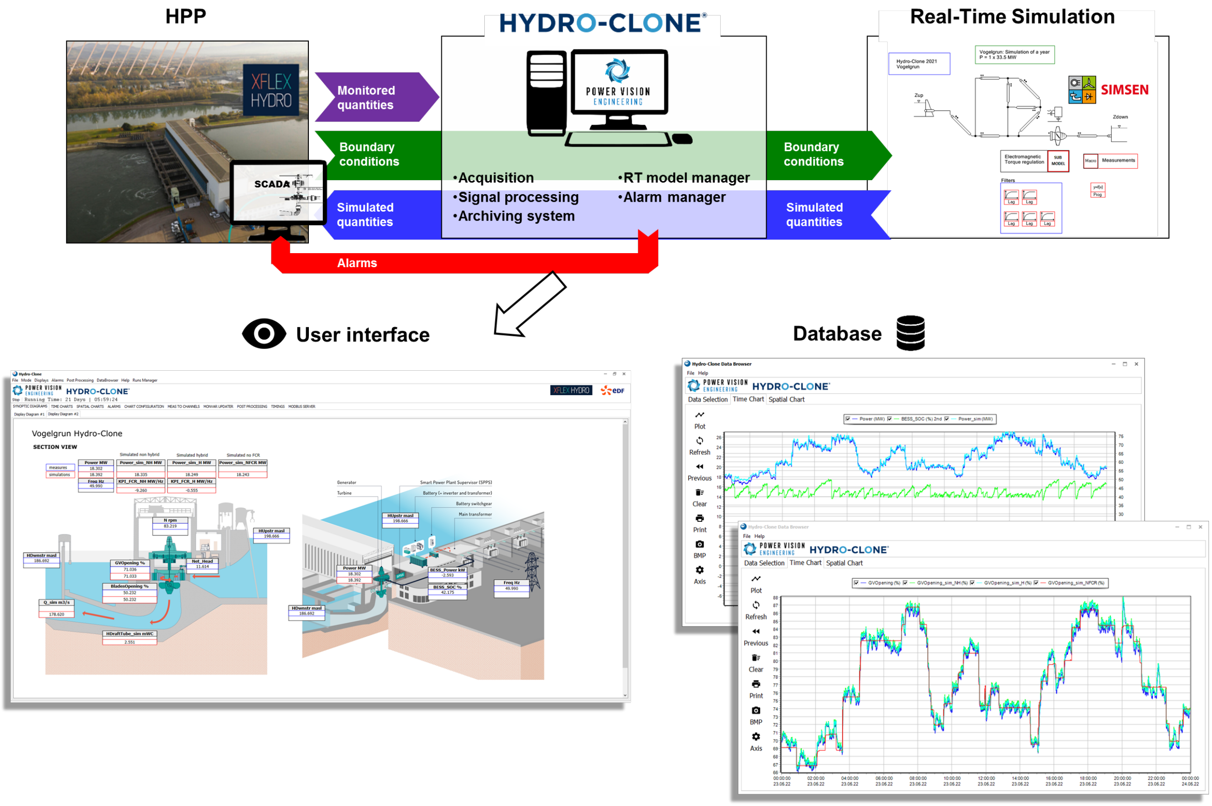

Figure 13 General concept of Hydro-Clone system based on real-time simulation.

The immediate benefit of this digitalization is that it allows the non-measured/non-measurable quantities to be monitored at any time without the physical installation of additional sensors. In the case of Vogelgrun HPP, it was decided to take advantage of this type of digitization to evaluate the impact of the BESS on the movements of the guide vanes opening (GVO) and the runner blade opening (RBO) by adding three additional real-time models operating in parallel in the Hydro-Clone. The characteristic and goal of each model is summarized in the Figure 14. The clone model #1 is the classic monitoring, which replicates the behaviour of the real unit by imposing the measured guide vane openings and blade pitch angle in the simulation. The clone model #2 includes the turbine governor model, with the guide vane opening set point and grid frequency as inputs. In this mode, the movement of the guides and blades is therefore a result, as they are driven by the turbine governor. This model enables to emulate the behaviour of the unit 1 without the BESS regardless of the mode of operation of the real unit. The clone model #3 follows the same philosophy as the model #2 except that the input is the low pass filtered grid frequency, as computed by the hybrid controller (Figure 2**Error! Reference source not found.**). This allows to replicate the behaviour of the hybridized unit 1 with the same control structure as when the BESS is activated. It was verified that the behaviour of models #2 and #3 correspond to the real unit when the battery is respectively deactivated or activated. Finally, clone #4 simulates the behaviour of the unit when the FCR response is disabled. This enables to identify the contribution of level regulation to the movement of GVO and RBO. These various versions of the digital twins with the unit controller provide a basis for comparison that allows direct confrontation of the hybrid and non-hybrid modes under the same operating conditions.

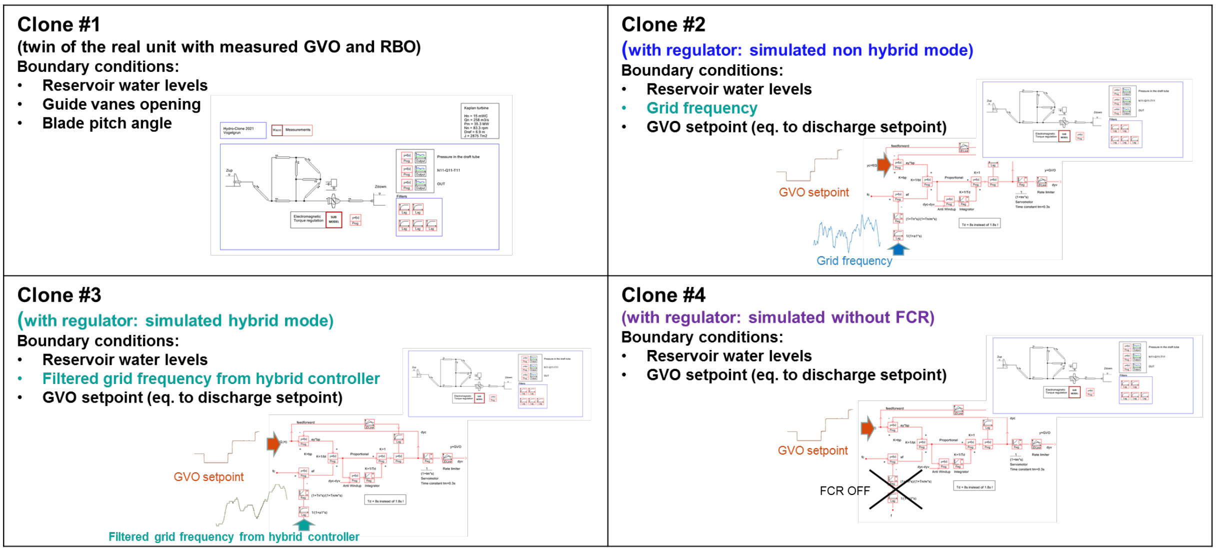

Figure 14 Summary and characteristics of the four real-time models deployed in Hydro-Clone.

3. First assessment of hybrid operation

In this section, first results of the assessment of hybrid operation are presented. First, the evaluation of the operating scheme are discussed. After that, the wear and tear assessment, with the identification of the most critical element is described. After that, the outcome of real-time models is presented.

3.1. Evaluation of the operating scheme

In Figure 15, boxplots of the SoC, BESS power and turbine power for one selected week is presented. Each boxplot shows the 1st, 10th, 50th (horizontal line in the rectangle), 90th and 99th percentiles. The red dot indicates the mean value of the sample. On the upper left figure, the BESS active power is plotted. 98% of the values were between +-500 kW during that week. 50% of the setpoints were between +-200kW. Hence for half of the time, the BESS was only loaded with nearly one third of its rated power. The upper right boxplot shows the distribution of the SoC of the same week. The SoC is maintained close 42.5% (mean value – red dot). Only on the 19th of May, the 99th percentile exceed 50% SoC. Due to the SoC Management, about 10% of the values are below 40% SoC. On the lower right plot, the distribution of the measurements of the turbine active power output is presented. On the first three days of the week, the output was higher compared to the rest of the week. Last but not least, on the lower right plot, the boxplot of the frequency of the grid is shown.

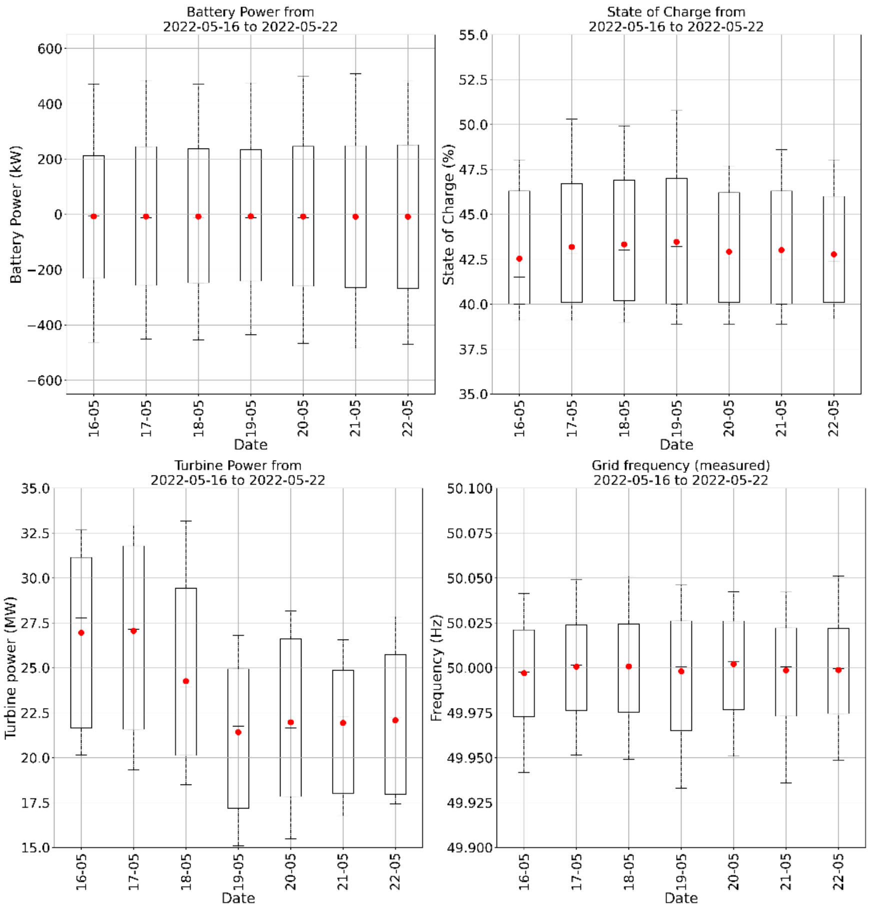

Figure 15 Boxplots of the BESS power, SoC, turbine power and grid frequency for one selected week. Boxplots showing 1st, 10th, 50th (horizontal line in the rectangle), 90th and 99th percentiles. Red dots indicate the mean value of the sample.

Figure 16 shows the boxplot for two frequency signals. On the left side, the measured grid frequency, is plotted. The FCR response of the hybrid system is calculated based on this signal. The response is split to the turbine and the BESS (Figure 2**Error! Reference source not found.**). Thereby, the speed governor of the TG unit receives an emulated frequency signal (Figure 16 right). One can note, that the percentiles of the emulated signals are closer to the nominal frequency, than the measured grid frequency. In consequence, the wear and tear of the TG unit is reduced.

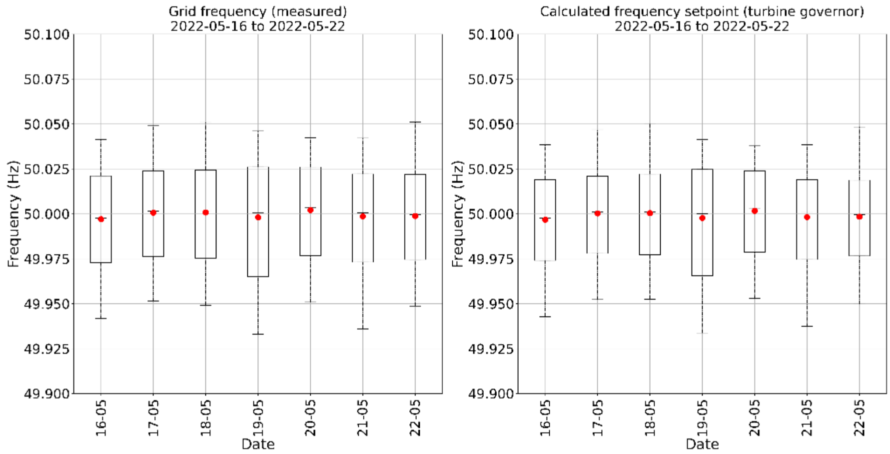

Figure 16 Boxplots of the measured and emulated frequency. Boxplots showing 1st, 10th, 50th (horizontal line in the rectangle), 90th and 99th percentiles. Red dots indicate the mean value of the sample.

Thanks to empirical battery's ageing model, the cells capacity loss was simulated ([8]). Simulation of the hybrid system over two years considering two times in a row real conditions (water level, flow rate and grid frequency) of the year 2018 showed that battery's cell state of health KPI (SoH) reaches 87%. In other words, battery looses 13% of its initial capacity after 2 complete years of hybridization operation. After one year of real operation, the SoH calculated by the BESS, decreased to 98%.One explanation is that the unit was not in hybrid operation during all times. Furthermore, a pre-defined power profile test with BESS was performed before the start of the hybrid operational phase. The BESS performance for that power profile will be periodically benchmarked. This will be used as a second KPI to evaluate the ageing of the BESS.

3.2. Wear and tear assessment

IN this section, the wear and tear assessment based on measurements is discussed. The calculated servomotor forces to actuate the blades were compared with measurements. Discrepancies lead to an adjustment of the measurements.
Even though some of the propeller curves may seem incomplete the on-cam points could be extracted to create the following comparison between CFD and prototype which shows a quite good agreement (**Error! Reference source not found.**Figure 17).

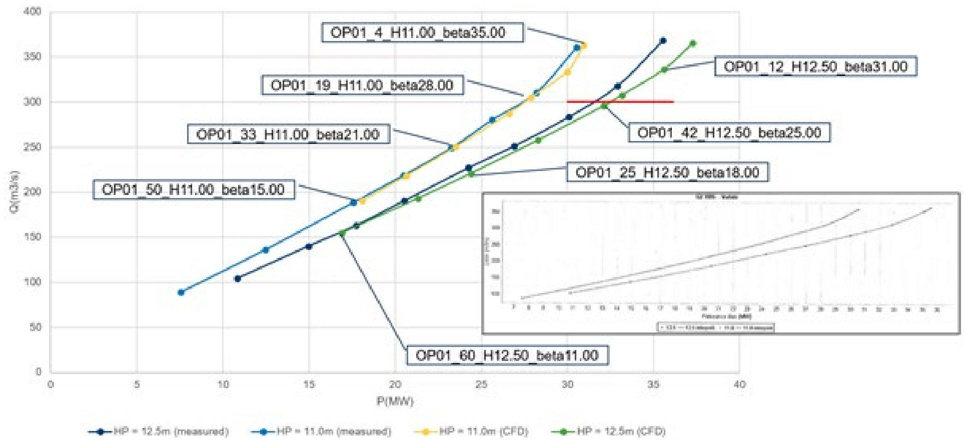

Figure 17 Comparison between CFD data and prototype data

In the simulations the critical component for a failure and an unplanned outage is identified with the link pin. A correlation of the servomotor force and the stress at the link pin can be established. The measured servomotor force variations lead to stress amplitudes and with the number of load cycles to utilization of the link pin. The utilization shows the reserve against failure.

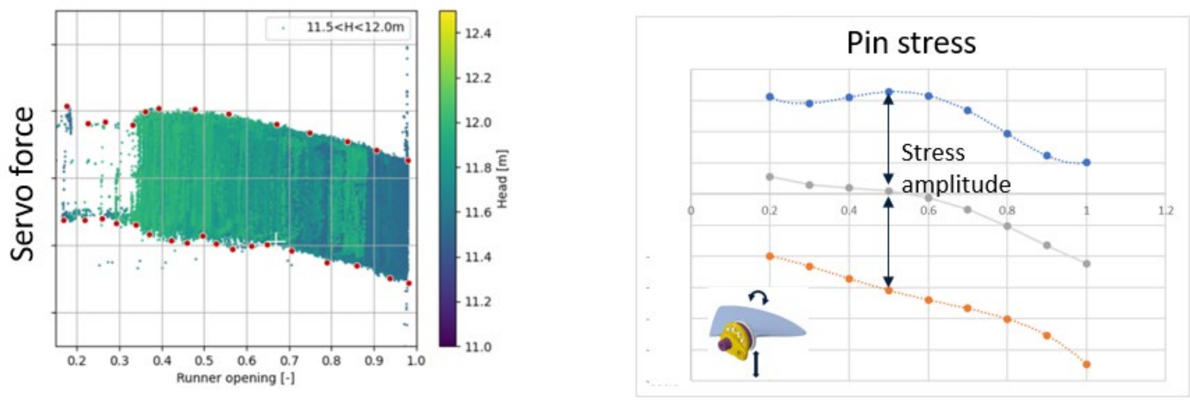

Figure 18: Measured servomotor forces and related pin stress.

The results from the above-mentioned FEM simulations are taken as an input for the Metris DiOMera indicator that compute wear and fatigue of the runner regulating mechanism based on real operation acquired through the monitoring system. Figure 19 shows the page summarizing the indicator “Wear of runner blade bearing” for unit 1.

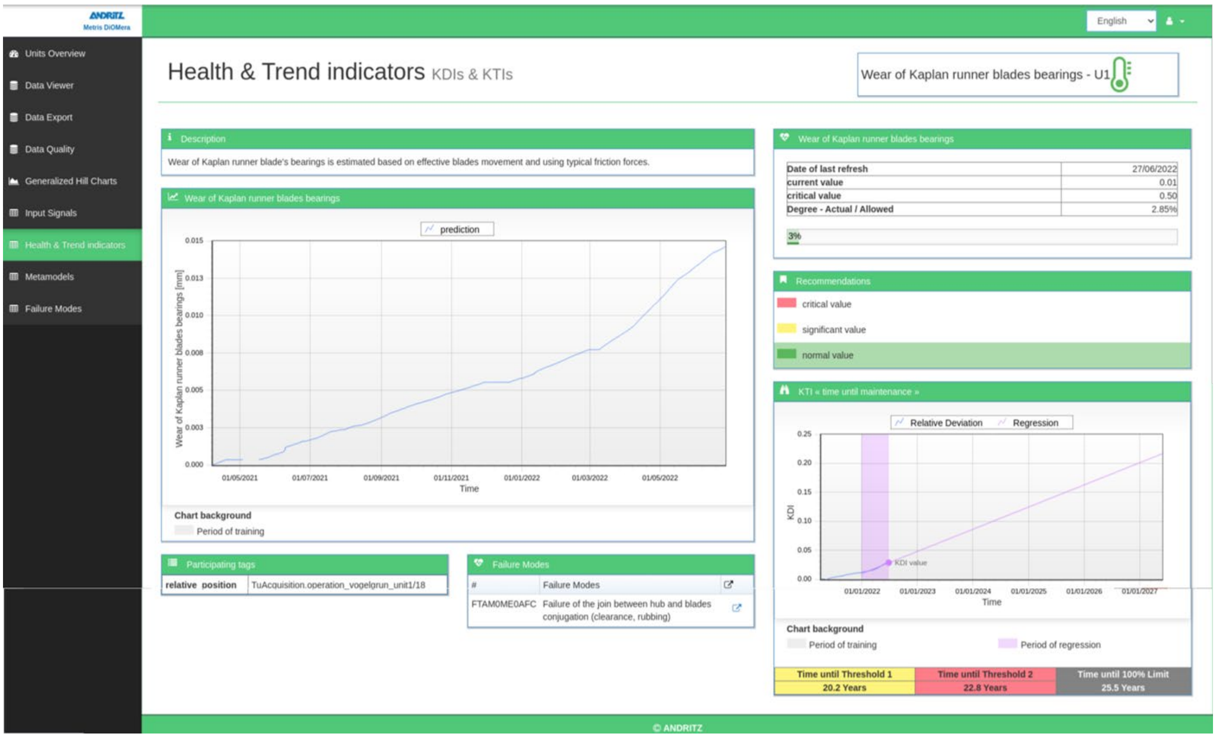

Figure 19: Metris DiOMera page summarizing the wear of runner blade bearing indicator of unit 1

3.3. Outcome of real-time models

The various declination of the digital twins presented in section 2.4 make it possible to evaluate the reduction in the mileage of the movements of the guide vane and blade openings that can be attributed to the battery during daily operation. The comparison of the simulated guide vane openings and runner blade openings in hybrid and non-hybrid mode for one day of operation is illustrated in Figure 20. As previously explained, the non-hybrid mode consists of using the grid frequency as the input to the turbine governor, while the hybrid mode uses the “HPP frequency set point” schematized in Figure 2**Error! Reference source not found.**, which corresponds to a low-pass filtered version of the grid frequency, to drive the turbine speed governor. Consequently, the hybrid mode reacts to a smoother frequency signal, which results in less movement of the GVO and RBO. As can be seen on the right side of Figure 20 **Error! Reference source not found.**, this reduction in movement is well noticeable, but is mostly present for small deviations around the mean value of the GVO and RBO positions.

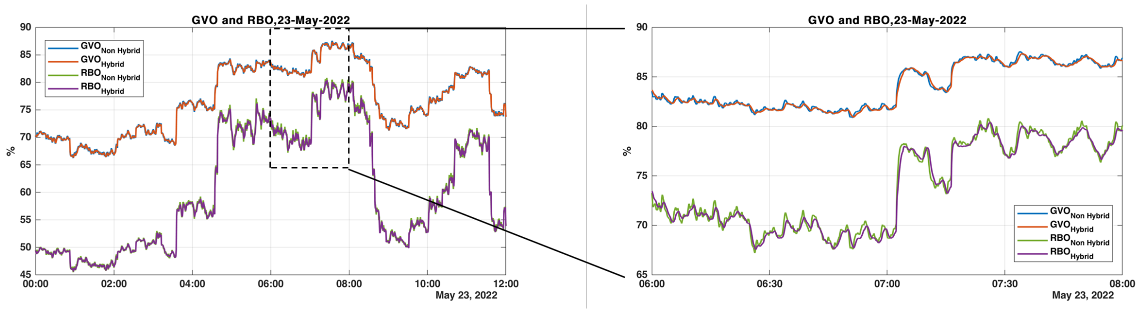

Figure 20: Comparison of the simulated guide vane opening and runner blade opening in hybrid and non-hybrid mode.

To further quantify the benefits of BESS on reducing the solicitation of control mechanisms, the Figure 21 shows the histogram of the GVO and RBO variation during one typical day of operation with the BESS. As it can be observed, the hybrid mode leads to a significant reduction in the number of small amplitude movements for both GVO and RBO, while the number of large-amplitude motions (>5mm) is not affected by the presence of BESS. This is expected since large amplitude movements are caused by the level control, whereas the BESS is designed to reduce the movement from the FCR provision. Nevertheless, these small movements have a significant impact on the total mileage of the GVO and RBO. In this way, the hybrid mode reduces the total mileage of the guide vanes by 43%, while the runner blade opening movement are reduced by 40.8%. It is worth noticing that the proportion of mileage that comes from level regulation represents 13.5% for GVO and 24.5% for RBO, respectively. The BESS also allows a significant reduction in the number of sign changes in the movement of GVO and RBO. Eliminating small movements reduces the number of panel changes by 67% for guide vane openings and 50.7% for runner blades openings. This type of result is encouraging to lower the fatigue load of mechanisms by reducing the number of cycles to which they are subjected.

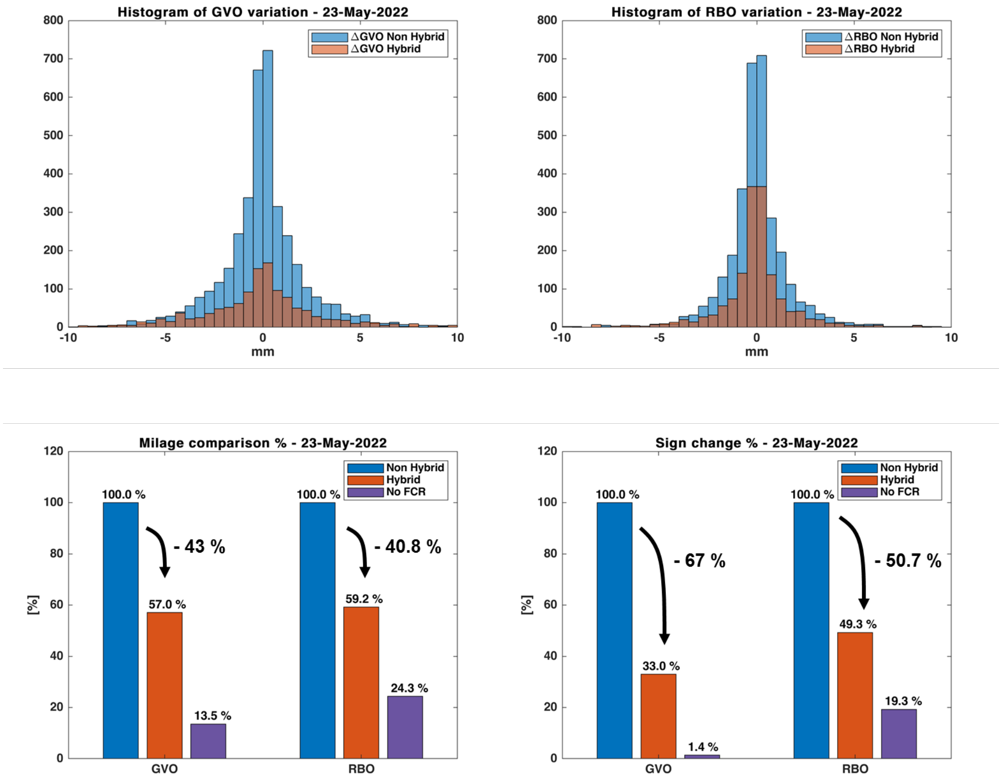

Figure 21 Assessment of the reduction in mileage and number of sign changes for the guide vane opening (GVO), and runner blade opening (RBO), in hybrid mode

4. Conclusion and outlook

It was demonstrated, that due to the hybridization the mileage of the guide vanes and runner blades could be reduced. In that regard, the estimated reduction in wear and tear at the beginning of the demonstration, matches the achieved reduction very well. With the collected measurements, the simulation models were tuned. This allows to run simulation for various scenarios with validated models and same conditions (e.g. discharge, head and frequency of the power system).
With the hybridization, the total mileage of the guide vanes could be reduced by 43%, while the runner blade opening movement were reduced by 40.8%. It was quantified that the proportion of mileage that comes from level regulation represents 13.5% for GVO and 24.5% for RBO, respectively. Also a significant reduction in the number of sign changes in the movement of GVO and RBO was observed (number of panel changes by 67% for guide vane openings and 50.7% for runner blades openings).
One boundary condition of the BESS sizing was that the BESS shall reach its end of life at the end of the demonstration phase. However, during the first half of the demonstration phase, the calculated SoH by the BESS is 98%.
Due to the sizing of the BESS (1.8% of the nameplate rating of one unit), the participation in other ancillary services markets is not feasible. However, with a larger BESS rating and capacity, the participation in markets, where also standalone BESS could be enabled.
Until the end of the project, different control strategies will be tested and evaluated in terms of achievable reduction in wear and tear as well as impact on the SoH of the BESS.
Finally, based on the experiences of all demonstrators of the XFLEX HYDRO project, a technical whitepaper and roadmap for European Hydropower fleet will be published.

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Author(s)

Wolfgang HOFBAUER made his PhD at the Vienna University of Technology in the field of controller optimization for large gas engines. After some years of experience in the automotive business he joined ANDRITZ HYDRO in 2008. His actual position is Product Manager for hydro turbine governors, which includes software development as well as modelling and simulation for grid code compliance.

Serdar KADAM received his master's degree in electrical engineering and his PhD degree from the University of Technology Vienna in 2012 and 2018, respectively. From 2011 to 2018, he worked within several Austrian and European smart grid research projects on the integration of renewables in distribution grids in Austria's largest research and technology organization. In 2018, he joined the Electrical Power Systems R&D group of ANDRITZ Hydro in 2018. His working topics include modelling and simulation of hydro power plants, grid code compliance and synchronous condensers

Magdalena NEUHAUSER received her master's degree in mathematics in 2010 from the University of Technology Vienna. In 2014 she received a PhD in mechanical engineering from Ecole Centrale de Lyon. Thereafter she joined the R&D department of ANDRITZ Hydro as part of the Turbine Physics team working mainly on predictive maintenance and data analysis. Since 2019 she is responsible for the Center of Competence Hydro Analytics.

Stefan LAIS graduated in Mechanical Engineering in 2001 from the University of Applied Sciences in Konstanz, Germany. From 2003 to 2012 he worked as a development engineer in the field of mechanical analyses of hydraulic machinery components in the R&D department of ANDRITZ Hydro in Zurich, Switzerland. Since 2012 Stefan Lais has been working in the Mechanical Engineering department in Kriens, Switzerland, where he is responsible for the Turbine Engineering & Technology team focusing on hydraulic layout, mechanical design, simulation, transient analysis, and field testing. At group level, he is responsible for the Centre of Engineering Competence Pelton and for the Centre of Competence Structural Analysis.

Luísa Fernandes Lameiro graduated in Civil Engineering at the University of Porto in 2009. In 2010 she joined ANDRITZ HYDRO working first as a project manager for turbine model tests and since 2016 as CFD designer of hydraulic turbines. Her work has been mainly focused on the development of Axial Turbines.

Erich WURM graduated in Mechanical Engineering at the Technical University of Graz in 1991. He thereafter joined ANDRITZ HYDRO (former VOEST MCE and VA TECH HYDRO) working as a calculation engineer within the field of structural mechanics. Since 2010 he has been heading the AH Mechanical Centre of Competence for Axial turbines.

Yves-Marie BOURIEN is graduated with a master degree in mechanic and automatic sciences from INSA and in renewable energy and hybrid systems from EUREC-Mines ParisTech. Since more than 10 years he works as research engineer at the solar department, and its service for renewables integration, of CEA Liten research center. His working topics are focused on renewable integration into power systems through energy system modelling, battery performance evaluation, flexibility analysis and stationary storage requirements.

Grégory PAÏS received his engineering degree in electronic and embedded software from the Polytech'Savoie school and his PhD degree in Informatics and Information system from the University of Savoie Mont-Blanc. He has joined in 2010 the Clipsol GDF-SUEZ factory to develop electronic products and embedded software to manage solar thermal systems for different applications from domestic heat storage to district heating network. Since 2019, he joined the CEA Liten in the Smart Grid laboratory to participate in the European XFLEX HYDRO project to simulate and develop the Energy management system for the Vogelgrun application.

Jean-Louis Drommi (IEEE member M'86– and senior member SM'01) is currently expert engineer at Electricité de France, Hydro Engineering Center. He deals with all electrical aspects of hydro projects both at design stage and maintenance. He has been working at Electricité de France since 1987. His former positions were: consulting engineer at EDF Nuclear Maintenance Department and test engineer at the General Technical Division; where he developed monitoring tools and test methods. J-L Drommi was awarded an engineering degree in 1986 from the Ecole Nationale Supérieure d'Ingénieurs Electriciens de Grenoble. He is senior member of IEEE and author of several papers in electrical and hydro field. He participates in CIGRE activities including generator and switchgear groups. He also currently leads

EDF involvement in the European project named XFLEX Hydro where a hybrid demonstrator is operating at the Vogelgrun plant on the Rhine river canal.

Christophe NICOLET graduated from the Ecole polytechnique fédérale de Lausanne, EPFL, in Switzerland, and received his Master degree in Mechanical Engineering in 2001. He obtained his PhD in 2007 from the same institution in the Laboratory for Hydraulic Machines. Since, he is managing director and principal consultant of Power Vision Engineering Sàrl in St-Sulpice, Switzerland, a company active in the field of optimization of hydropower transients and operation. He is also external lecturer at EPFL in the field of "Transient Flow".

Christian LANDRY graduated from the Ecole polytechnique fédérale de Lausanne, EPFL, in Switzerland, and received his Master degree in Mechanical Engineering in 2010. He obtained his PhD in 2015 from the same institution in the Laboratory for Hydraulic Machines. Since 2016, he is working for Power Engineering Sàrl in St-Sulpice, Switzerland, on transient phenomena, simulation and analysis of the dynamic behavior of hydroelectric power plants and their interactions with the power network.

Matthieu DREYER graduated from the EPFL, the Swiss Federal Institute of Technology in Lausanne, Switzerland, and received his master's degree in mechanical engineering in 2010. He obtained his PhD in 2015 from the same institution in the Laboratory for Hydraulic Machines. After two years of post-doctoral research in the same laboratory, he joined Power Vision Engineering Sàrl in 2017. Since then, he is responsible for the integration of Hydro-Clone system in hydropower plants

Carme Valero born in Barcelona. She has been part of the Fluid Mechanics department of the UPC (Universitat Politència de Catalunya) since 1989 and has been an Associate Professor since 1997.
Her research activity has focused on the dynamic behavior of hydraulic machines. Within this line of research, she has been part of the research team in international and national projects.
At the international level, in recent years its participation in the European HYPERBOLE project financed by the EU and in the HYDRODINA Phase II project financed by the main European turbine manufacturers. The result of the research has led to five doctoral theses and publications in several journals.
At the national level, she has participated in various competitive projects financed by the Ministry and in various technology transfer projects for Spanish companies.
She is currently the main researcher for the UPC of the European project XFLEX-HYDRO (2019-2023) led by the EPFL. Since September 2019 she has been the director of the Center for Industrial Diagnosis and Fluid Dynamic.

Alexandre Presas graduated in Aeronautics from the TU München in 2009. In 2014 he received a PhD in mechanical engineering from the Universitat Politècnica de Catalunya. After doing a postdoctoral degree in Tsinghua University, in 2019 he started his actual position as Associate Professor at the Universitat Politécnica de Catalunya. His main research is focused on the dynamic behaviour of hydraulic turbines and the application of AI techniques in hydropower.

David VALENTIN graduated from the Polytechnic University of Catalonina, UPC, in Barcelona, and received his degree in Industrial Engineering in 2013. He obtained his PhD in 2018 from the same institution in the Center for Diagnosis and Fluid Dynamics (CDIF). Since 2020, he is working in UPC as Lecturer in the Fluid Mechanics Department and researching topics related with Fluid-Structure Interaction, specially applied to hydropower. He is expert in both experimental and structural numerical simulations in hydraulic turbines.