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Specification for Instrumentation, Data Acquisition and Control System for SSG Pilot Plant at Kvitsøy, Norway

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Preface

This report is an initial draft for specifications of instrumentation, data acquisition and control system for SSG pilot plant at the Island of Kvitsøy, Norway.

The SSG energy converter is based on wave overtopping principle utilizing three reservoirs for capturing the offshore wave power. The project is partly founded by the EU 6th framework program (WAVESSG) and this report has been realized according to the Co-operation agreement between WEVEnergy AS (Norway) and Aalborg University, Department of Civil Engineering.

This paper is intended to give an overview on instrumentation for monitoring the efficiency of the Converter and the performance of the device. Real-time control of plant and data monitoring and storage are the main objectives of the control system.

Revision History

Version	*Date*	*Author*	*Comment*
0.0	10.07.2006	Lucia Margheritini	Initial draft
0.1	07.08.2006	LM / JPK	JPK comments incl.

1 Introduction

In order to provide specifications for instrumentation, data acquisition and control system for SSG pilot plan, in the following paragraphs are presented:

- the objectives of instrumentation,
- the significant parameters describing SSG working conditions,
- data acquisition and control system for monitoring the SSG converter and its efficiency.

As the system must be flexible in its nature, the present report is not meant to be the definitive answer to the need of setting up a reliable monitoring equipment but better intends to be the kick-off for improvement and implementation of the suggested outlines also from other partners of the project.

Appendix A is presenting tables with: signals to be acquired, data to be calculated and data to be post-processed. This proposal is based on nowadays idea and intuition, and it should be considered open to rearrangements.

Appendix B reports brochures of pressure transducers, Buoy, ADCP and camera.

1.1 Objective

The objective of the present paper is to provide a map of the surveillance instrumentation on the SSG device.

Specific object of data monitoring and storage is to evaluate the efficiency of the conversion of the wave power into electrical power by the device. This is done by calculating the available wave power from the wave climate and relating it to the power output:

$$\eta = \frac{P_{output}}{P_{wave}}$$

It is then important to evaluate the dispersion and the absorption of the incoming power through the device step by step by monitoring:

1) P_{wave}: power at the sea (offshore waves),

2) P_{crest}: power in overtopping,

3) P_{res}: power in reservoirs,

4) P_{tur}: power in turbine,

5) P_{net}: power of the generator and to the grid.

The relative efficiencies are determined by:

$\eta_{crest} = \frac{P_{crest}}{P_{wave}}$, indicates the efficiency of the overtopping;

$\eta_{res} = \frac{P_{res}}{P_{wave}}$, indicates the efficiency of the reservoirs;

$\eta_{tur} = \frac{P_{tur}}{P_{wave}}$, indicates the efficiency of the turbines.

$\eta_{net} = \frac{P_{net}}{P_{wave}}$, indicates the efficiency of the grid connections.

The control and data acquisition system to monitor the significant parameters as well as the equations needed to calculate the power at specific steps will be presented in the following paragraphs.

2 Wave power offshore

The available wave power at sea is evaluated as:

$$P_{wave} = \frac{\rho g^2}{64\pi} H_S^2 T_E$$

where T_E can be estimated as $T_E = T_P/1.15$

2.1 Data acquisition system for wave recording

The data acquisition system should enable the evaluation of the **whole spectrum of waves** , from which the following parameters could be processed:

1. $\boldsymbol{H_S}$ = significant wave height
2. $\boldsymbol{T_P}$ = peak period
3. $\boldsymbol{T_E}$ = energy period = m_{-1}/m_0, where m_n is the n-th moment of the wave spectrum defined as

$$m_n = \int_0^\infty f^n S(f) df$$

The data acquisition system for these significant parameters should be installed in front the SSG location at a distance of approximately 100 m. The wave measuring device could be a pressure transducer with a mooring system to the bottom of the sea, a self contained ADCP located again at the bottom of the sea or a Wave Rider Buoy (see brochures, Appendix B). These instruments can provide both H_S and T_P and also waves and currents direction. Real time data would be gathered and analyzed in SCADA system after they have been transmitted by wire or radio. The choice of the instrument for wave measuring must take into account installation difficulties and risk of loss due to rough condition of the sea.

3 Power in overtopping

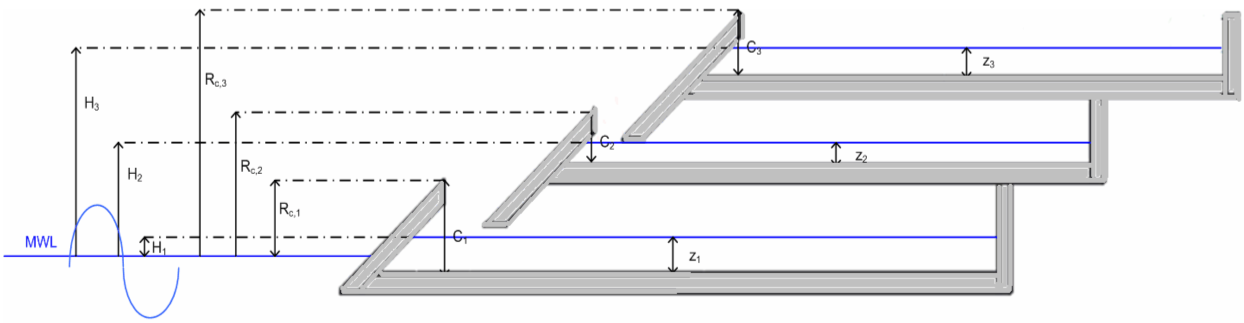
The power in the overtopping is the potential power in the overtopping water as it overtops the crest of the structure. The overtopping power is related to the crest height relative to the MWL ($R_{c,j}$) and the flow rate. To evaluate the power in the overtopping, the following expression is used:

$$P_{crest} = \sum_{j=1}^{3} q_{ov,j} R_{C,j} \rho g$$

where $R_{c,j}$ = crest height related to the MWL and $q_{ov,j} = q_{res,j} + q_{turbine,j} + q_{spillout,j} - q_{spillin,j}$ is total overtopping flow rate related to each reservoir (j = counter of reservoirs), ρ = density of the sea water ≈ 1025 Kg/m^3 and g = gravity ≈ 9.82 m/s^2.

The overtopping flow is not directly measurable, therefore the evaluation of the total overtopping flow rate has to be done indirectly as indicated by the four terms mentioned above. The $q_{spillout,j}$ is a positive contribute to the overtopping into the *j*-reservoir and *spilout* indicates that this flow has overtopped the crest, but due to limited reservoir capacity, it is spilling out. In the case that no one of the reservoirs exceed the vertical capacity C_j , the spill flow rate is zero. The last term $q_{spillin,j}$ is equal to the $q_{spillout,j}$ of the above reservoir (if present, else zero), i.e. $q_{spillout,j+1}$. This term has to be subtracted, as is has been counted as overtopping into the above reservoir.

Definition Sketch



3.1 Different contributes

Following, the total overtopping flow rate's components are described and expressions for their calculation are given.

- $q_{res,j}$. The water inside the reservoir is moving ideally only vertically (dz_j). The flow rate of this movement is given by:

$$q_{res} = A_j \frac{dz_j}{dt} \quad [\text{m}^3/\text{s}]$$

where z_j is obtained as average of the three pressure transducers in the j-reservoir and A_j is the horizontal cross sectional area of the reservoir (that can be dependent on the water level in the reservoir due to none vertical reservoir walls, eg. inside of the ramp) .

- $\boldsymbol{q_{\mathrm{turbine},j}}$. The volume flow through the individual turbines is calculated from the turbine head H_j; a turbine specific expression on following form can be used:

$$Q_1' = B_3 n_1'^3 + B_2 n_1'^2 + B_1 n'_1 + B_0$$

where B_0, B_1, B_2, B_3 are fixed coefficients; the unit volume is given by $Q'_1 = \frac{q_{turbine,j}}{D^2 \sqrt{H_j}}$ and the rotation speed n is given by $n'_1 = \frac{nD}{\sqrt{H_j}}$; H_j is the turbine head [m] and D is the turbine runner diameter [m].

Furthermore the calculation of $q_{\mathrm{turbine},j}$ will need to take into account the start and stop losses, which will also influences the flow rates. H_j is calculated as average of the three pressure transmitters in the individual reservoirs.

It is expected that these expressions will be provided by the turbine designers (TUM/NTUN).

- $\boldsymbol{q_{\mathrm{spill},j}}$. The precise evaluation of this term is not easy but from simple discharge formulas it is possible to give the a first esteem of the spilling flow rate as:

$$q_{spill,j} = \mu c_j b_j \sqrt{2 g c_j}$$

where μ is a coefficient of discharge in the range of 0.415 - 0.385 depending on the geometry of the overtopping ramp, c_j is the exceeding vertical capacity of the reservoir, C_j: $c_j = z_j - C_j$, (z_j = reservoir level only based on fore most pressure transducer) and b_j is the width of the ramp.

An example of a rough calculation of the overtopping flow considering the four different terms is now presented (see definition sketch).

Input: $\boldsymbol{H_{jt}, H_{jt-1}, A_j, z_{jt}, z_{jt-1}, C_j}$

Output: $\boldsymbol{q_{ov,j}}$

for j=1,2,3

$$q_{res,j,t} = A_j \frac{z_{j,t} - z_{j,t-1}}{\Delta t}$$

$q_{turbine,j,t}$ = $f(H_j$, time since start, time since stop, speed, …$)$. To be specified by TUM.

$c_j = z_j - C_j$

If $c_j > 0$ *then*

$$q_{spillout,j,t} = \mu c_j b_j \sqrt{2gc_j}$$

else

$$q_{spillout,j,t} = 0$$

If j=1or 2 then

$$q_{spillin,j,t} = q_{spillout,j+1,t-1}$$

If j=3 then

$$q_{spillin,j,t} = 0$$

$q_{ov,j,t} = q_{\text{res},j,t} + q_{\text{turbine},j,t} + q_{\text{spillout},j,t} - q_{\text{spillin},j,t}$

next j

Once that the overtopping flow rate is calculated, it is possible to make a comparison between the laboratory results from Kofoed, 2005, where the dimensionless derivate of the overtopping discharge with respect to the vertical distance z is:

$$Q_{ov1} = \frac{dq/dz}{\sqrt{gH_S}} = A\exp^{B\frac{z}{H_S}+C\frac{R_{C,1}}{H_s}}$$

and A, B and C are empirical coefficients.

The overtopping rate for individual reservoir can be estimated using:

$$q_n(z_1,z_2) = \int_{z_1}^{z_2} \frac{dq}{dz}dz = \int_{z_1}^{z_2} \sqrt{gH_S}\,A\exp^{B\frac{z}{H_S}}\exp^{C\frac{R_{C,1}}{H_S}}dz = \sqrt{gH_S^3}\,\frac{A}{B}\exp^{C\frac{R_{C,1}}{H_S}}\left(\exp^{B\frac{z_2}{H_S}} - \exp^{B\frac{Z_1}{H_S}}\right)$$

where z_1 and z_2 denote the lower and upper vertical boundary of the reservoir, respectively; generally $z_1 = R_{C,n}$ and $z_2 = R_{C,n+1}$, n being the reservoir number.

4 Power in reservoirs

The power in each reservoir is calculated as:

$$P_{res,j} = \rho g H_j q_j$$

Where the total flow rate is $q_j = q_{\text{turbine},j} + q_{\text{res},j}$.

and H_j = water level in reservoirs relative to MWL.

5 Power in turbines

The power in the turbines should be given by an expression based on head (and speed?) that Technical University of Minchin will provide. Instantaneous tail water level should be used for turbine head and reservoir level from the closest pressure transducer as there could be a non-irrelevant drop of the water level due to the presence of the turbine itself. Any way, this drop could be of a non relevant magnitude compared to the fluctuations of the level in the reservoir due to waves and turbulence in general.

6 Power of generator and power to the grid

Direct measurement

7 Forces on ramp

In order to monitor forces on the ramps, three pressure transducers will be installed on each plate. Each of them will be in the middle of a sub-area determined by the length $a_{j,i}$ along the ramp (i = instrument position counter on each ramp) and the width b; the force measured by the specific pressure transducer is derived by the following expression:

$$F_{j,i} = p_{j,i} a_{j,i} b$$

where $p_{j,i}$ is the measured pressure.

The total force on the plate is the sum of the three measured forces on it:

$$F_j = F_{j,1} + F_{j,2} + F_{j,3}$$

The total force's moment arm on one plate is then:

$$a_j = \frac{\sum_{i=1}^{3} F_{j,i} l_i}{\sum_{i=1}^{3} F_{j,i}}$$

where l_i is the position of the transducer on the ramp.

8 Data acquisition system for reservoirs sensors

The data acquisition system will record data at 5 *Hz*.

The data acquisition system should enable the evaluation of the following parameter:

1. ***MWL*** = long term average
2. $\boldsymbol{z_j}$ = average over three transmitters of reservoir water level, relative to reservoir bottom
3. $\boldsymbol{H_j}$ = mean water level in reservoirs MWL

4. $R_{C,j}$ = crest height, relative to MWL

Therefore, all the 3 reservoirs will be equipped with three pressure transducers located at 1.5 m from the walls (Figure 1) to read from each the water level and to extrapolate the mean value. Three pressure transducers will be placed on each plate to measure wave loadings on the structure and one will be allocated to measure the tailwater level, for the total of 19 pressure transducers..

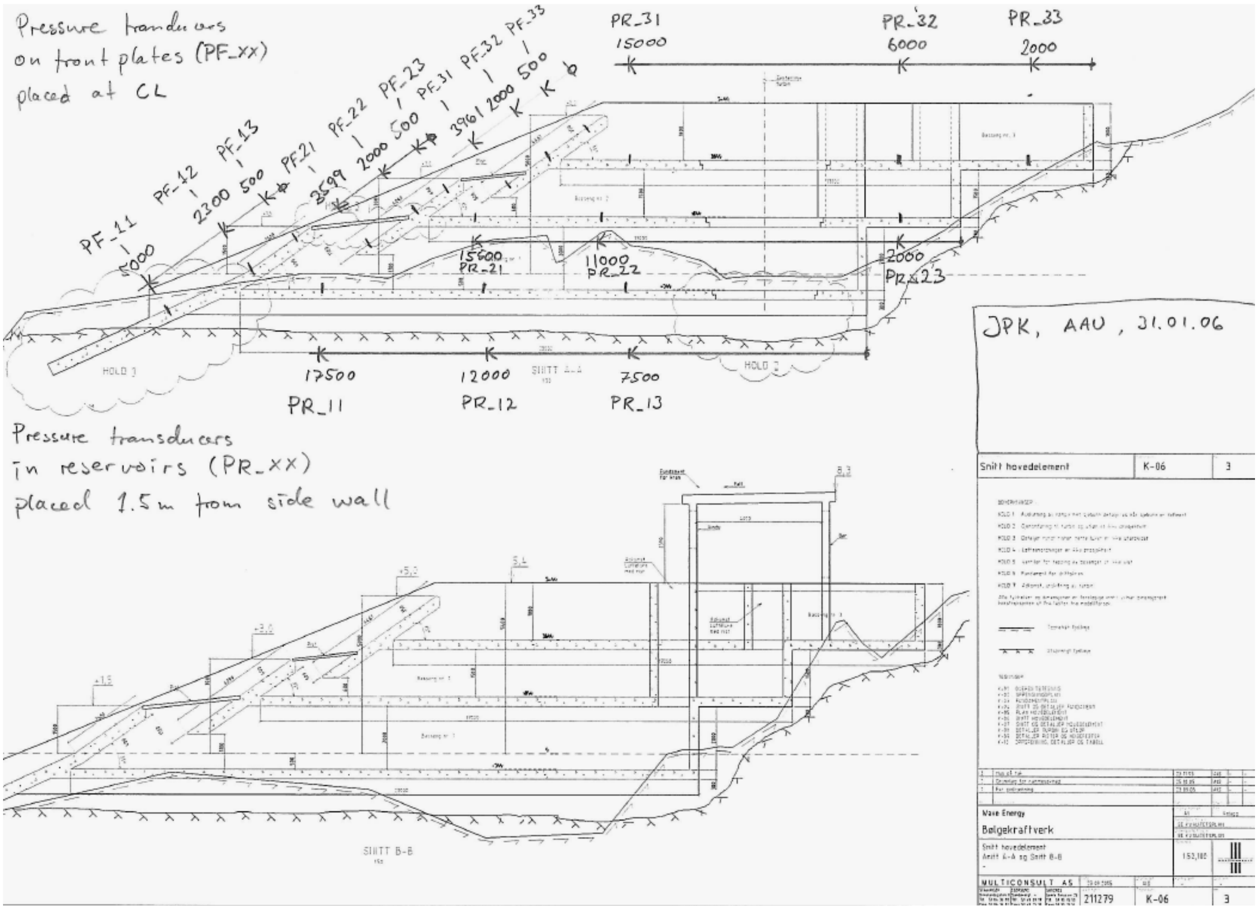


Figure 1

It is suggested that a standard insert with a flange is made. This could look as indicated in the sketch (Figure 2). The flange should be cast into the concrete structure, with a tube (min. 50 x 200 mm) attached to it. This tube should then be connected to the routing pipe for the wire, going from the measuring point to the control room. There should be a string in the routing pipe for pulling through the wire.

For the transducers to be placed in the reservoirs the plate, to which the transducer is attached, will differ from the one shown in the sketch below (Figure 2).

In these cases the transducers should be elevated some cm's above the reservoir floors in order to avoid getting sand etc. in the transducers. However, the flange and hole in the concrete should be similar to the ones in the fronts.

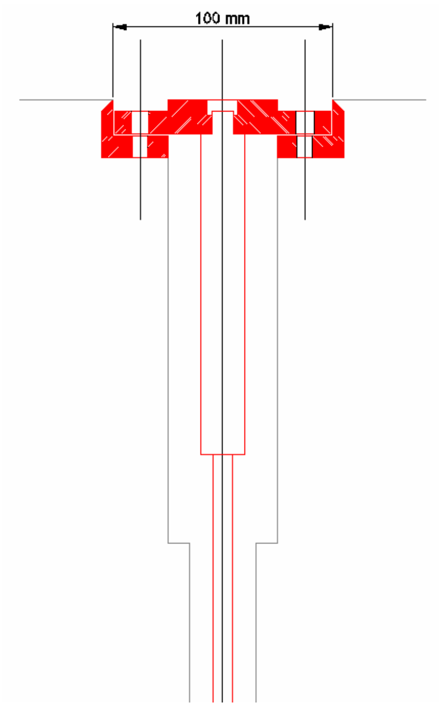


Figure 2

9 Conclusions and Recommendations

- Different instruments for wave recording have been suggested.
- Significant parameters for data acquisition have been described and formulas for their calculation have been presented. The evaluation of the power in overtopping presents some difficulties that will probably generate uncertainties on the efficiency at that stage; however rearrangements are possible.
- The use of 19 pressure transducers and their position on the pilot plant have been specified.
- A description of the data acquisition and control system have been provided.

The system should be flexible in its nature, as it is almost unavoidable that there will be a need for eg. attaching other types of sensors, incorporate data from other sources, etc. As is seems now, there will probably be a need to import data from a separate PC (wave measurements) and maybe also from data on the web (wind data, as these will be provided from DNMI weather station at Kvitsøy.

The data time series for each signal channel have to be stored in files suitable for exchange with third parties, eg. as tab separated ASCII files, each holding, say, one hour records. These data files should automatically be sent to an off site FTP server on a daily basis. Furthermore, statistical values for each signal channel should be calculated and stored in a database. Eg. for the signals from the pressure transducers on the reservoir fronts, this could be max. and deviation, for wave recordings it should be significant wave height and peak period, for generator power is should be max. and total production, etc. Select statistical values should be made available to the public on a webpage.

10 References

Kofoed, J. P.: *Model testing of the wave energy converter Seawave Slot-Cone Generator*. Hydraulics and Coastal Engineering No. 18, ISSN: 1603-9874, Dep. of Civil Eng., Aalborg University, April 2005.

11 Appendix A

Tables with acquired, calculated and post processed data.
Found on following pages.

12 Appendix B

Data sheets on proposed sensors.
Found on pages following Appendix A.

Acquired signal – real time data for Programmable Logical Circuit (PLC)

Tag ID	Instrument	Sensor description	Placement	Sample freq.	Output Type	Range limits	Trigger criteria
PRES_PR11	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Lower reservoir, front position	5 Hz	4-20 mA	0-100 mH2O	
PRES_PR12	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Lower reservoir, middle position	5 Hz	4-20 mA	0-100 mH2O	
PRES_PR13	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Lower reservoir, rear position	5 Hz	4-20 mA	0-100 mH2O	
PRES_PR21	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Middle reservoir, front position	5 Hz	4-20 mA	0-100 mH2O	
PRES_PR22	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Middle reservoir, middle position	5 Hz	4-20 mA	0-100 mH2O	
PRES_PR23	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Middle reservoir, rear position	5 Hz	4-20 mA	0-100 mH2O	
PRES_PR31	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Upper reservoir, front position	5 Hz	4-20 mA	0-100 mH2O	
PRES_PR32	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Upper reservoir, front position	5 Hz	4-20 mA	0-100 mH2O	
PRES_PR33	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Upper reservoir, front position	5 Hz	4-20 mA	0-100 mH2O	
PRES_PF11	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Lower ramp, upper position	5 Hz	4-20 mA	0-100 mH2O	
PRES_PF12	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Lower ramp, middle position	5 Hz	4-20 mA	0-100 mH2O	
PRES_PF13	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Lower ramp, lower position	5 Hz	4-20 mA	0-100 mH2O	
PRES_PF21	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Middle ramp, upper position	5 Hz	4-20 mA	0-100 mH2O	
PRES_PF22	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Middle ramp, middle position	5 Hz	4-20 mA	0-100 mH2O	
PRES_PF23	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Middle ramp, lower position	5 Hz	4-20 mA	0-100 mH2O	
PRES_PF31	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Upper ramp, upper position	5 Hz	4-20 mA	0-100 mH2O	
PRES_PF32	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Upper ramp, middle position	5 Hz	4-20 mA	0-100 mH2O	
PRES_PF33	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	Upper ramp, lower position	5 Hz	4-20 mA	0-100 mH2O	
PRES_TW	Druck RTX 1930, HF Jensen, or similar	Pressure transducer	In tail water	5 Hz	4-20 mA	0-100 mH2O	
FF_1		Force Transducer	Lower ramp	5 Hz	SG full-bridge	0-100 kN	
FF_2		Force Transducer	Middle ramp	5 Hz	SG full-bridge	0-100 kN	
FF_3		Force Transducer	Upper ramp	5 Hz	SG full-bridge	0-100 kN	

Calculated signal – real time data for Programmable Logical Circuit (PLC)

Tag ID	Description	Expression	Sample freq.	Trigger criteria
c1	Exciding vertical capacity in lower reservoir	c1=z1- C1	5 Hz	
c2	Exciding vertical capacity in middle reservoir	c2=z2- C2	5 Hz	
c3	Exciding vertical capacity in upper reservoir	c3=z3- C3	5 Hz	
QRES1	Flow rate in lower reservoir	QRES1=A1x(z1t-1-z1t)/deltat	5 Hz	
QRES2	Flow rate in middle reservoir	QRES2=A2x(z2t-1-z2t)/deltat	5 Hz	
QRES3	Flow rate in upper reservoir	QRES£=A3x(z3t-1-z3t)/deltat	5 Hz	
QTURBINE1	Flow through the turbine in lower reservoir		5 Hz	
QTURBINE2	Flow through the turbine in middle reservoir		5 Hz	
QTURBINE3	Flow through the turbine in upper reservoir		5 Hz	
QSPILL_OUT1	Spilling out flow rate in lower reservoir	QSPILLOUT1=0.38c1b(2gc1)*1/2	5 Hz	
QSPILL_OUT2	Spilling out flow rate in middle reservoir	QSPILLOUT2=0.38c2b(2gc2)*1/2	5 Hz	
QSPILL_OUT3	Spilling out flow rate in upper reservoir	QSPILLOUT3=0.38c3b(2gc3)*1/2	5 Hz	
QSPILL_IN1	Spilling in flow rate in lower reservoir	QSPILLOUT2= - 0.38c2b(2gc2)*1/2	5 Hz	
QSPILL_IN2	Spilling in flow rate in middle reservoir	QSPILLOUT3= - 0.38c3b(2gc3)*1/2	5 Hz	
QTURB_1	Flow through the turbines in lower reservoir		5 Hz	
QTURB_2	Flow through the turbines in middle reservoir		5 Hz	
QTURB_3	Flow through the turbines in upper reservoir		5 Hz	
QOV1	Overtopping flow rate in lower reservoir	qov,1 = qres,1 + qturbine,1 + qspillout,1 - qspillin,1	5 Hz	
QOV2	Overtopping flow rate in middle reservoir	qov,2 = qres,2 + qturbine,2 + qspillout,2 - qspillin,2	5 Hz	
QOV3	Overtopping flow rate in upper reservoir	qov,1 = qres,3 + qturbine,3 + qspillout,3 - qspillin,3	5 Hz	
MWL	Mean water level	Long term average	5 Hz	
RC_1	Crest level in lower reservoir		5 Hz	
RC_2	Crest level in middle reservoir		5 Hz	
RC_3	Crest level in upper reservoir		5 Hz	
Z1	Mean water level in lower reservoir related to the bottom	z1=(z1'+z1"+z1'")/3	5 Hz	
Z2	Mean water level in middle reservoir related to the bottom	z2=(z2'+z2"+z2'")/3	5 Hz	
Z3	Mean water level in upper reservoir related to the bottom	z3=(z3'+z3"+z3'")/3	5 Hz	
H1	Head in lower reservoir related to MWL	H1= z1-MWL	5 Hz	
H2	Head in middle reservoir related to MWL	H2= z2-MWL	5 Hz	
H3	Head in upper reservoir related to MWL	H3= z3-MWL	5 Hz	
A1	Horizontal cross sectional area in lower reservoir	A1=[l1+a(1-Z1/C1)]b	5 Hz	
A2	Horizontal cross sectional area in middle reservoir	A2=[l2+a(1-Z2/C2)]b	5 Hz	
A3	Horizontal cross sectional area in upper reservoir	A3=[l3+a(1-Z3/C3)]b	5 Hz	
F_11	Force on the lower area of the lower ramp	F1,1=a1,1bp1,1	5 Hz	
F_12	Force on the middle area of the lower ramp	F1,2=a1,2bp1,2	5 Hz	

F_13	Force on the upper area of the lower ramp	F1,3=a1,3bp1,3	5 Hz	
F_21	Force on the lower area of the middle ramp	F2,1=a2,1bp2,1	5 Hz	
F_22	Force on the middle area of the middle ramp	F2,2=a2,2bp2,2	5 Hz	
F_23	Force on the upper area of the middle ramp	F2,3=a2,3bp2,3	5 Hz	
F_31	Force on the lower area of the upper ramp	F3,1=a3,1bp3,1	5 Hz	
F_32	Force on the middle area of the upper ramp	F3,2=a3,2bp3,2	5 Hz	
F_33	Force on the upper area of the upper ramp	F3,3=a3,3bp3,3	5 Hz	
POWOV_1	Power in overtopping in lower reservoir		5 Hz	
POWOV_2	Power in overtopping in middle reservoir		5 Hz	
POWOV_3	Power in overtopping in upper reservoir		5 Hz	
POWRES_1	Power in lower reservoir		5 Hz	
POWRES_2	Power in middle reservoir		5 Hz	
POWRES_3	Power in upper reservoir		5 Hz	
POWTURB_1	Turbine production in lower reservoir		5 Hz	
POWTURB_2	Turbine production in middle reservoir		5 Hz	
POWTURB_3	Turbine production in upper reservoir		5 Hz	
POWGEN	Production of the generator		5 Hz	

Post processed data for SCADA system – to be stored in database

Tag ID	Description	Expression	Trigger criteria	Publish on the web
PEAKP	Peak period			X
SIGWH	Significant wave height			X
T_E		TE=Tp/1.15		
SPEC_W	Specral width parameter	e=1-(m2*2/(m0m4))*1/2		
POW_W	Offshore power			X
WAVEDIR	Wave direction			X
WAVEDIR_SPR	wave spread			
WINDDIR	Wind direction			X
WINDSPEED				X
QOV1_A	Average overtopping value in lower reservoir			
QOV2_A	Average overtopping value in middle reservoir			
QOV3_A	Average overtopping value in upper reservoir			
QOV1_V	Overtopping deviation in lower reservoir			
QOV2_V	Overtopping deviation in middle reservoir			
QOV3_V	Overtopping deviation in upper reservoir			
QRES1_A	average flow rate in lower reservoir			
QRES2_A	average flow rate in middle reservoir			
QRES3_A	average flow rate in upper reservoir			
QRES1_V	Flow rate deviation in lower reservoir			
QRES2_V	Flow rate deviation in middle reservoir			
QRES3_V	Flow rate deviation in upper reservoir			
QSPILLOUT,1_V	Spilling out flow rate deviation in lower reservoir			
QSPILLOUT,2_V	Spilling out flow rate deviation in middle reservoir			
QSPILLOUT,3_V	Spilling out flow rate deviation in upper reservoir			
QSPILLOUT,1_A	Average spilling out flow rate in lower reservoir			
QSPILLOUT,2_A	Average spilling out flow rate in middle reservoir			
QSPILLOUT,3_A	Average spilling out flow rate in upper reservoir			
QTURB1_A	Average flow throgh turbines in lower reservoir			
QTURB2_A	Average flow throgh turbines in middle reservoir			
QTURB3_A	Average flow throght turbines in upper reservoir			
QTURB1_V	Flow rate deviation through turbines in lower reservoir			
QTURB2_V	Flow rate deviation through turbines in middle reservoir			
QTURB3_V	Flow rate deviation through turbines in upper reservoir			
POWOV1_A	Average of the power in overtopping in lower reservoir			
POWOV1_V	Deviation of the power in overtopping in lower reservoir			

POWRES1_A	Average of the power in lower reservoir			
POWRES1_V	Deviation of the power in lower reservoir			
POWOV2_A	Average of the power in overtopping in middle reservoir			
POWOV2_V	Deviation of the power in overtopping in middle reservoir			
POWRES2_A	Average of the power in middle reservoir			
POWRES2_V	Deviation of the power in middle reservoir			
POWOV3_A	Average of the power in overtopping in upper reservoir			
POWOV3_V	Deviation of the power in overtopping in upper reservoir			
POWRES3_A	Average of the power in upper reservoir			
POWRES_V	Deviation of the power in upper reservoir			
POWOVTOT_A	Average of the total power in overtopping			X
POWOVTOT_V	Deviation of the total power in overtopping			
POWRESTOT_A	Average of the total power in reservoirs			X
POWRESTOT_V	Deviation of the total power in reservoirs			
TURBPOW_V	Deviation of the turbine production			
TURBPOW_M	Maximum turbine production			X
TURBPOW_A	Average turbine production			X
OVEFF1_A	Overtopping average efficiency in lower reservoir			
OVEFF2_A	Overtopping average efficiency in middle reservoir			
OVEFF3_A	Overtopping average efficiency in upper reservoir			
RESEFF1_A	average efficiency in lower reservoir			
RESEFF2_A	average efficiency in middle reservoir			
RESEFF3_A	average efficiency in upper reservoir			
TURBEFF1_A	Turbines average efficiency in lower reservoir			
TURBEFF2_A	Turbines average efficiency in middle reservoir			
TURBEFF3_A	Turbines average efficiency in upper reservoir			
GENEFF	Generator efficiency			
OVEFF_TOT	average total efficiency in overtoppings			
RESEFF_TOT	average total efficiency in reservoirs			
TURBEFF_TOT	average total turbines efficiency			
POWGrid_V	Deviation of the power to the grid			
POWGrid_M	Maximum power to the grid			X
POWGrid_A	Average power to the grid			X
EFFTOT	Total efficiency			X