LIFE NEXUS Seminar

Energy recovery in a DWTP using an innovative micro-hydropower system based on the integration of a Pump as Turbine and an energy storage

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This project has received funding from the LIFE financial instrument of the European Commission LIFE17 ENV/ES/000252

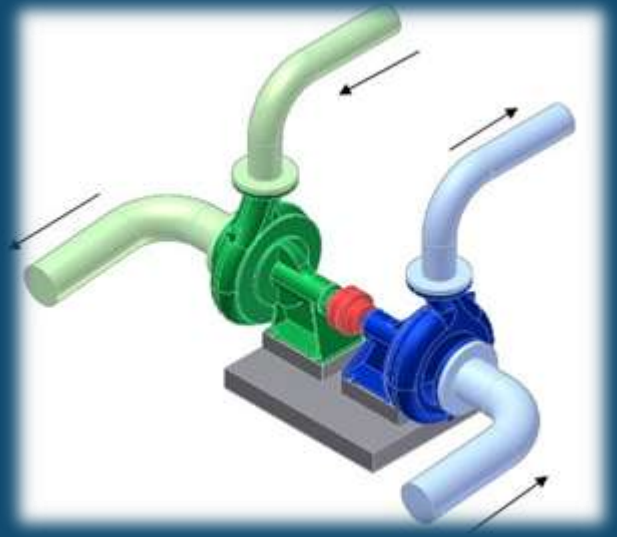
Kaunas, 12th September 2023

LIFE NEXUS objectives and outcomes

Objective 1: Explore the potential for **mini-hydropower** in European water industry. Inventory of sites with basic data based on **head and flow** (GIS-database).

Objective 2: For the more promising locations from the general inventory: Assessment of the technical and economic feasibility of **new mini-hydraulic projects**, considering **regulatory and policy context** of each country.

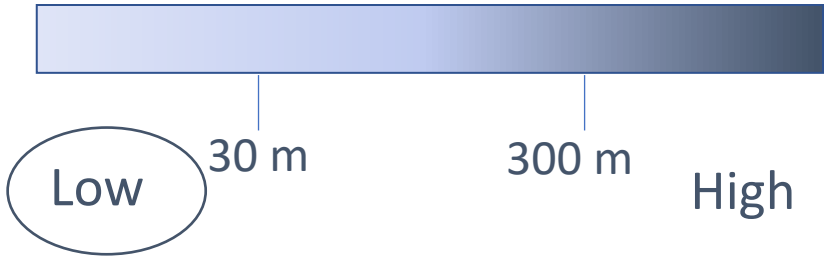
Objective 3: **Demonstration** of a mini-hydraulic prototype (45 kW) at Porma Drinking Water Treatment Plant (DWTP) in Leon (Spain).
Innovative integration of **Pump as Turbine** (PaT) with a **battery storage**.



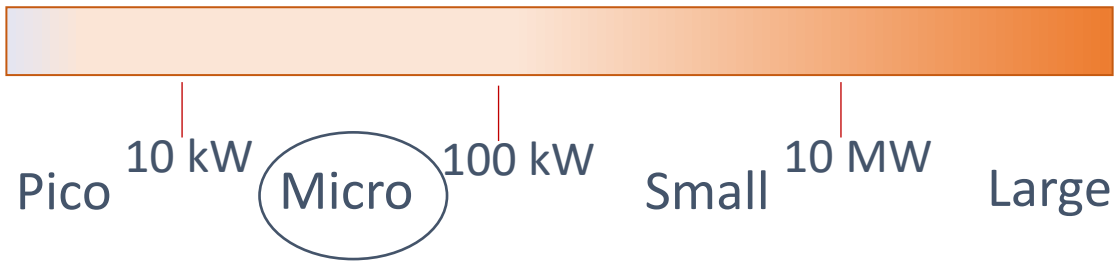
Pump as Turbine technology

Selection of technology

Hydraulic head



Installed capacity



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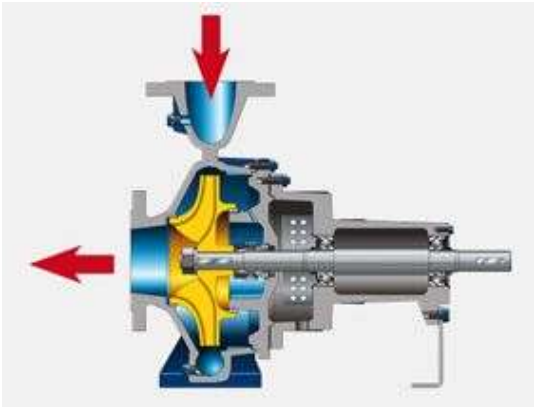


Pump as Turbine (PaT) *vs* conventional machines (Francis, Pelton, etc.)

+ Lower cost and payback period (2-5 years)
+ Bigger market manufacturers
+ Large operating range (P and Q)
+ Simple management and operation

PaT installed (< 100 kW) in Ireland, France, Spain, Chile, Morocco and USA

- Low efficiency when operating outside the best efficiency point

Selection of PaT

Dedicated presentation by Mariano Mirete (AQUATEC):

"Maximizing the amount of annual energy obtained based on real PAT curves and real data from the installation (flow and pressures)"

LIFE NEXUS
Demosite

Technology

LIFE NEXUS demosite

Valefresno (Leon, Spain)
Porma Drinking Water Treatment Plant

Demonstration of a mini-hydraulic prototype (45 kW)
Innovative integration of **Pump as Turbine** (PaT) with a **battery storage**.

- ✓ Generation of **215 MWh/year** of renewable electricity, currently dissipated by a Pressure Reduction Valve (PRV) located at the entrance of the DWTP.
- ✓ **100% reduction of the GHG emissions** from the DWTP as the energy generated is higher than the total energy demand of the installation (163.55 ton $CO_{2\ equiv}$/year)

LIFE NEXUS demosite: initial situation

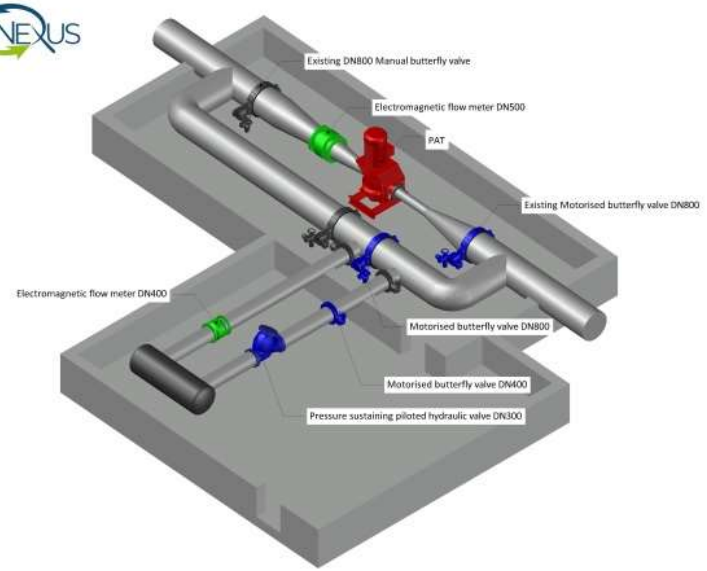
- ✓ Pressure Reduction Valve (PRV)

- ✓ Pre-oxidation
- ✓ Coagulation/ Flocculation
- ✓ Flotation
- ✓ Sand filters
- ✓ Final disinfection

Technology

LIFE NEXUS demosite: final situation

PaT prototype



$Q_{PaT\ desgin}$ = 205 L/s

AQUATEC responsable for the PaT selection and prototype design

Construction of the Hydropower Plant: on going (to be finished by 1st quarter of 2023)

PROPOSED INSTALLATION AND HYDRAULIC OPERATION

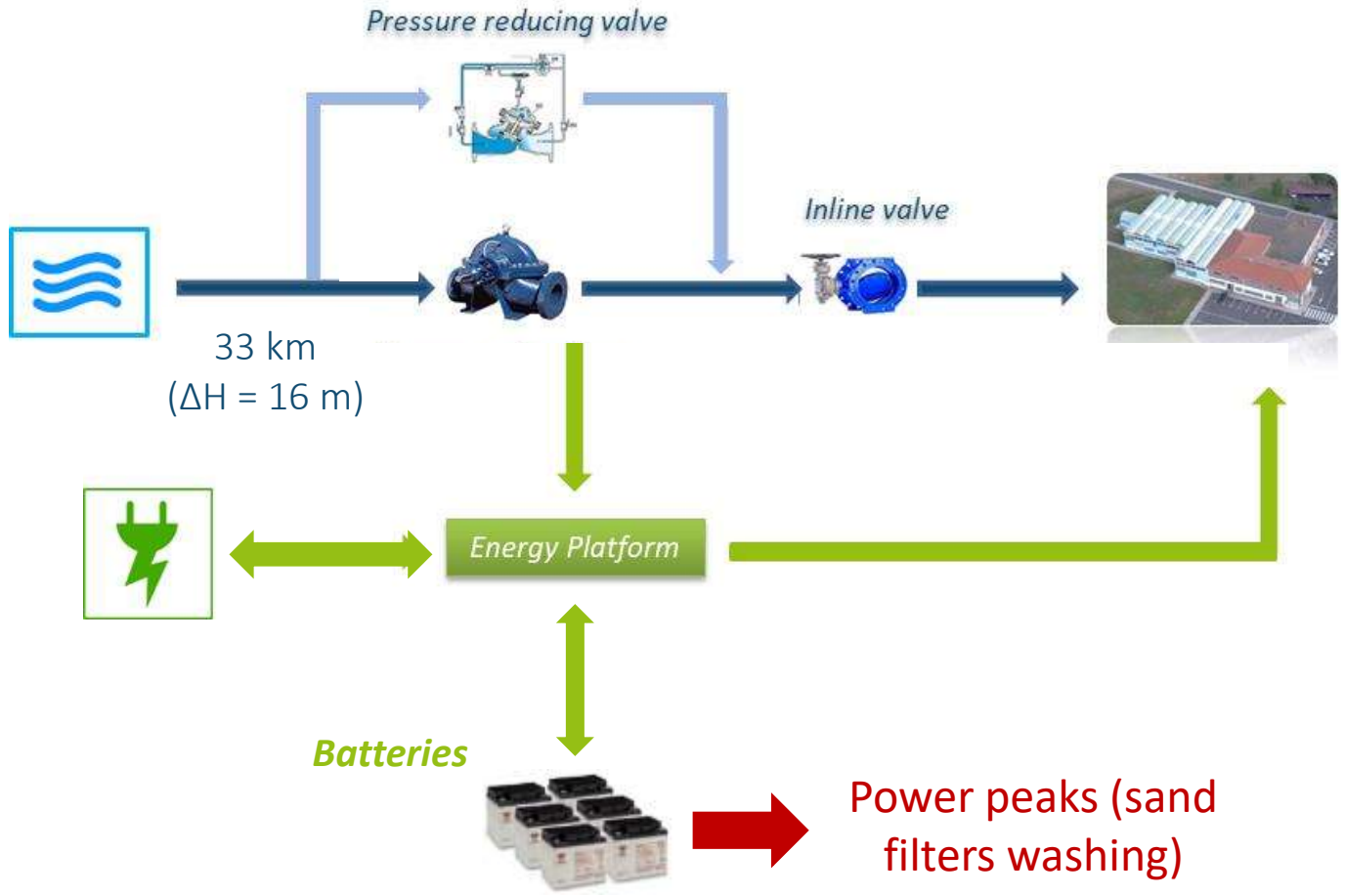
Hydraulic operation

Regulation of water flow in the PaT

Water: 2 scenarios
$Q_{entrance} \leq 205$ L/s

Hydraulic operation

Regulation of water flow in the PaT



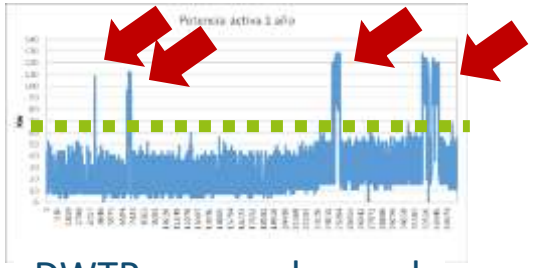
Water: 2 scenarios

$Q_{entrance} \leq 205$ L/s

$Q_{entrance} > 205$ L/s

Energy generation/use

PaT



DWTP energy demand

Analysis of energetic production

Technology

Analysis of energetic production

Simulation of energy scenarios

Usually the energy generated in the PaT is higher than the instantaneous energy consumed in the DWTP. The excess energy will accumulate in the batteries to cover periodic punctual consumption peaks of the **washing filter system**.

Objectives: Optimise **energy generation & use**, minimize **grid exchange** and optimize **batteries life cycle**

1. Development of a specific PaT model
2. Development of a model of the total system (**TRNSYS**): PaT, batteries and loads (pumps, blowers, lighting, etc.)
3. Generation of scenarios: Economic / technical / size **on going**

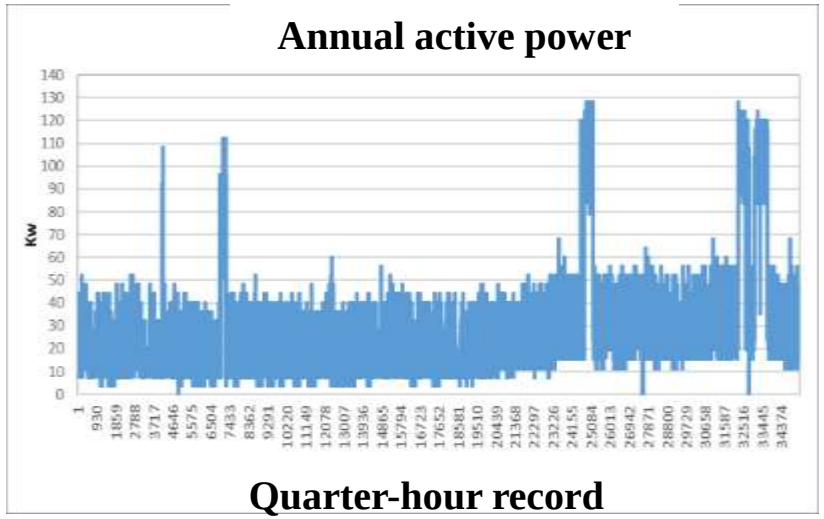
Technology

1. Specific PaT model

Operating curves provided by the PaT manufacturer:

$$P = 0.0001 \cdot \mathrm{Q}^2 - 0.0079 \cdot \mathrm{Q} - 2{,}3928$$
$$\Delta\mathrm{H} = \ 0.000029 \cdot Q^2 - 0.012776 \cdot \mathrm{Q} + 7.949$$

[P (kW), Q (m^3/h) and ΔH (mwc)]



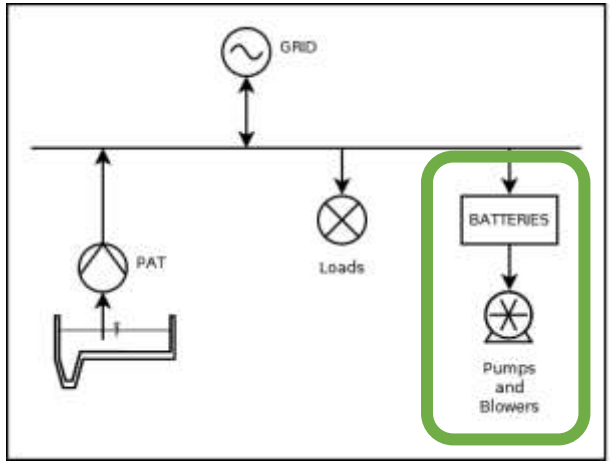
- The model's input data are the **flow records** that enter the DWTP and the **hourly energy demand** values collected over a year (simulation period).

- The model generates the **energy balances** and the **operating status** of each of the systems (operating regime, load level, etc.) including the needs for energy exchange with the grid.

2. Model of the total system

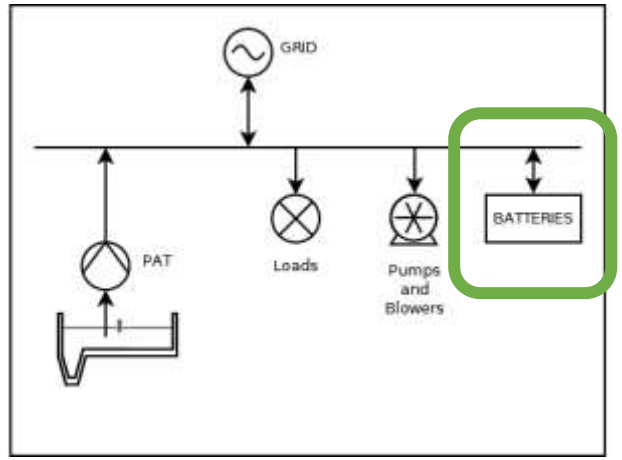
Elements integrated in the model: PaT, batteries and loads (pumps, blowers, lighting, etc.)

Two **basic operation schemes**, depending on the interaction between **storage** and the rest of the system



battery exclusively supplies the pumps and blower demands (sand filters washing equipment)

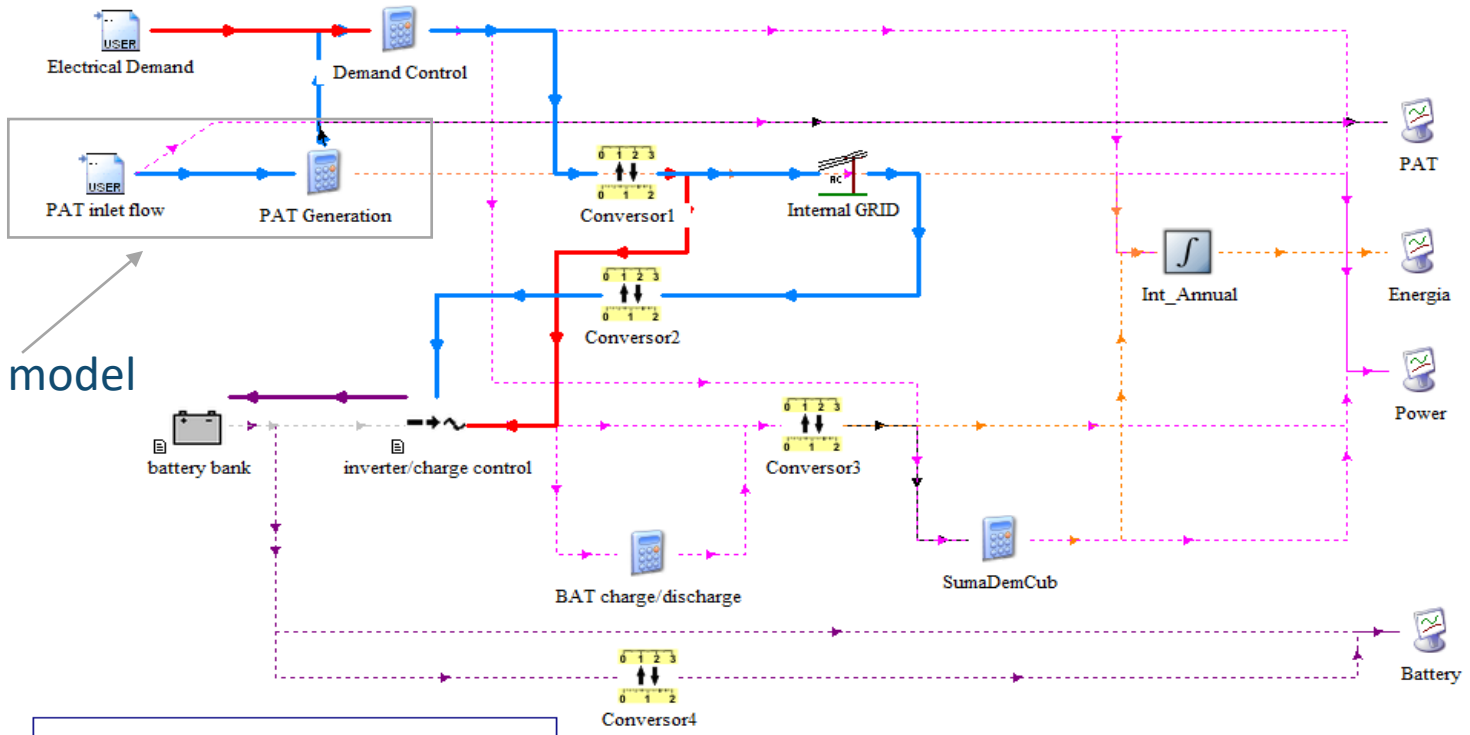
PaT discharges into the **internal network**, to power the different loads and charge the batteries



battery covers the overall needs of the system

2. Model of the total system

TRNSYS



Specific PaT model

Technology

3. Generation of scenarios

On going

A **sensitivity analysis of the simulation model** is being carried out, varying the key design and operation parameters (battery size, hours of use of the equipment, weather conditions, etc.), allowing the analysis of the **energy flows production** under different scenarios.

Simulation data will be verified/validated with the measurements obtained during **real operation**.

→ The aim is to establish the **best operating strategies** for the system and identifying improvements in the implementation of battery-powered PaT systems in other locations.

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