SCCER SoE

SWISS COMPETENCE CENTER for ENERGY RESEARCH
SUPPLY of ELECTRICITY

SCCER-SoE Annual Conference 2016

In cooperation with the CTI

Energy
Swiss Competence Centers for Energy Research

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Commission for Technology and Innovation CTI

PiezoEel: An Energy Harvester for Mountain Stream Monitoring

Grégory Emery, Sylvain Richard*,*
*Herbert Keppner**, Joseph Moerschell*, Cécile Munch-Alligné*, Laurent Rapillard**
** HES-SO Valais-Wallis, Rawyl 47, 1950 Sion, ** HE-ARC, Eplatures-Grise 17, 2300 La Chaux-de-Fonds*

Hes·so VALAIS WALLIS
School of Engineering

1. What is the problem?

Mountain streams may flow in deep valleys with little sunshine available to power a photovoltaic panel that would recharge a data-logger and sensor battery.

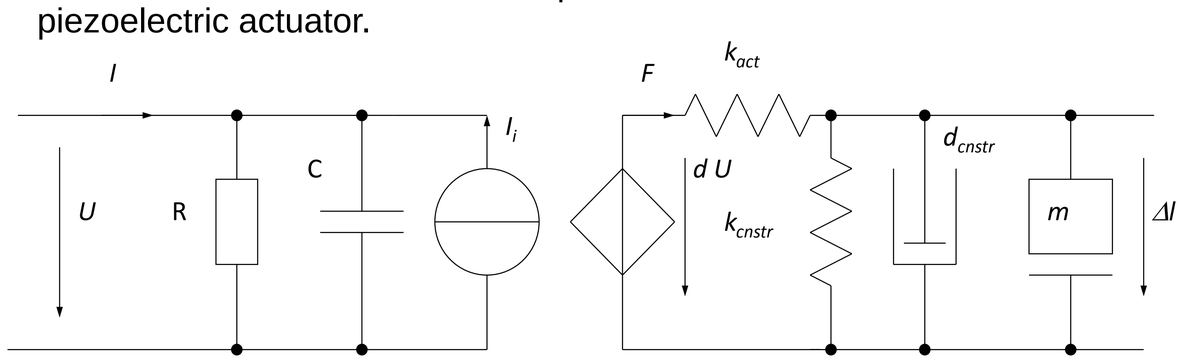
As an illustration, the picture shows the Borgne river at the entrance of Val d'Hérens.
Modern data-loggers may consume not more than 100mW typ., but depending on the number of sensors, and their sampling rate, average power consumption can increase to 1W or more. Also, GSM data communication requires several W of power.
The objective is to develop an alternative power source capable of supplying an average power of 1W. The energy shall be collected from the water flow.

2. Piezoelectric energy harvesting from water

The basic approach of this development is to use piezoelectric elements instead of a turbine / generator group as classically used. This is done for several reasons:

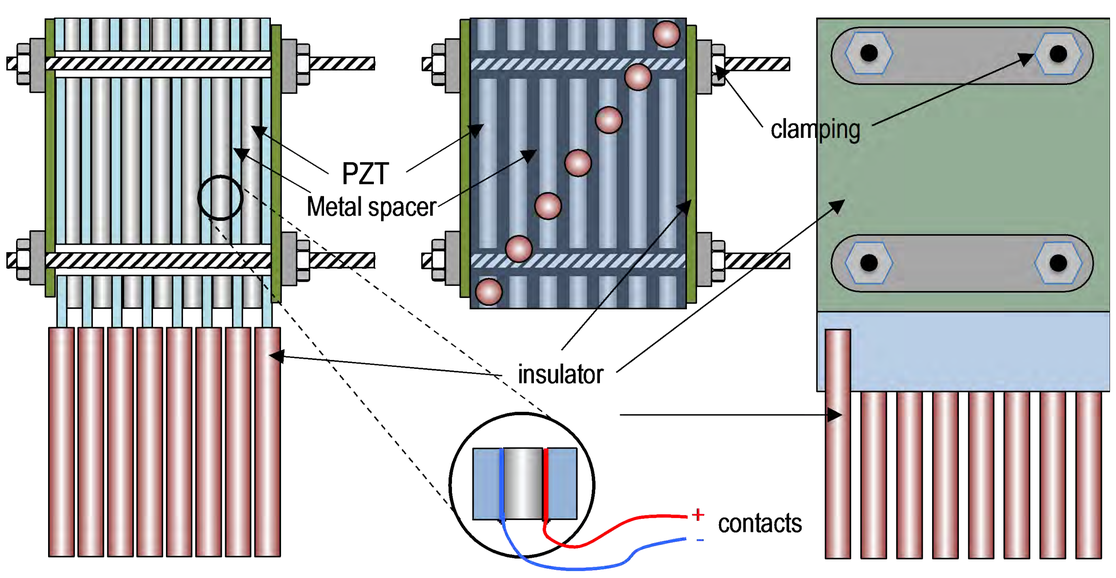
- A water channel structure (concrete or steel construction) shall be avoided to keep the system light and easy to install.
- At 1W power level, the efficiency of a turbine / generator set shall be modest.
- The energy to be harvested shall be motion energy of the water, rather than potential energy due to a water gradient.

Piezoelectric elements are very stiff, and important electric polarization occurs if high forces are exerted on them. On the other hand, water is practically not stiff, but flows over long distances with considerable speed. Between the two, the proposed harvester must therefore do an important adaptation of 'mechanical impedance'.
The schematic below shows an equivalent electric circuit model of a piezoelectric actuator.



3. Harvester concept

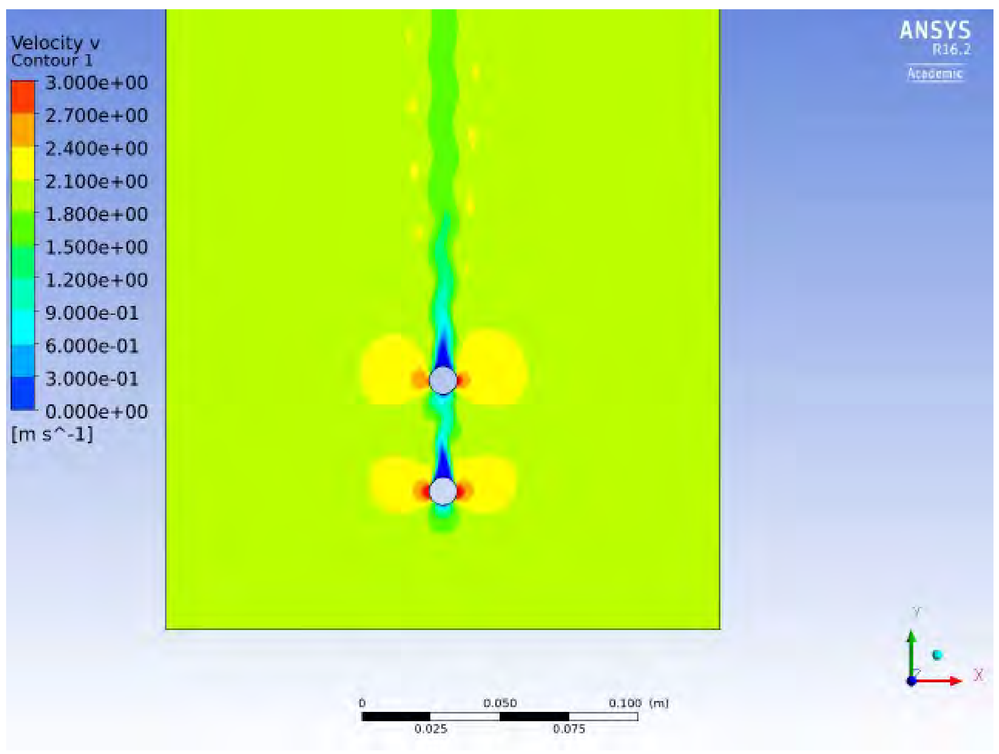
A set of piezoelectric elements is compressed within a staple of steel plates. The preconstraint is necessary since piezo elements can only work in compression. Steel rods are screwed into the steel plates. The length of these rods and their diameter shall be adapted such that their resonance frequency is excited by turbulent water flow around the tips reaching into the water stream.



4. First simulation results

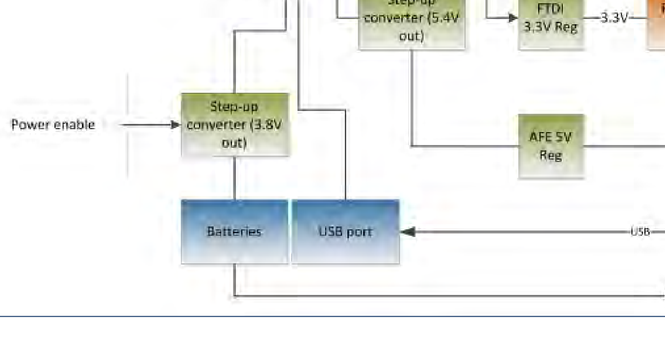
Favorable configuration of rods plunging into ware was sought. I turns out that

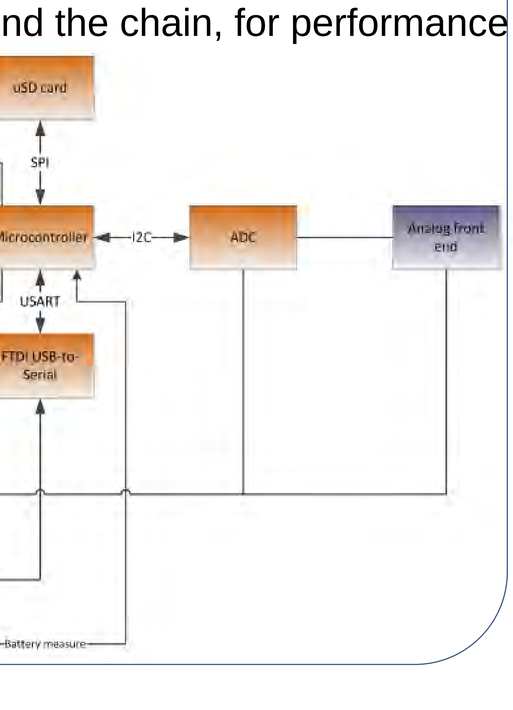
- An obstacle, typically of same diameter and spaced by one diameter should be placed in front of the vibrated rod.
- Having several rods in parallel increases the vibration force generated by turbulent water flow.
- Vibration frequencies in the range of several 10Hz, depending on rod diamter.



5. Preliminary tests

A test set-up was built to evaluate the energy transmission performance from rod vibration to the piezo elements. While the electric energy generation function could be successfully shown, the available electric output power is still too small. The mechanical impedance adaptation must be improved in the next iteration of the design.





6. Block diagram of harvesting chain from water to battery

Monitoring functions are added around the chain, for performance evaluation.