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Hydrokinetic Micro-Power Generation in Small Rivers - a New Approach

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Motivation

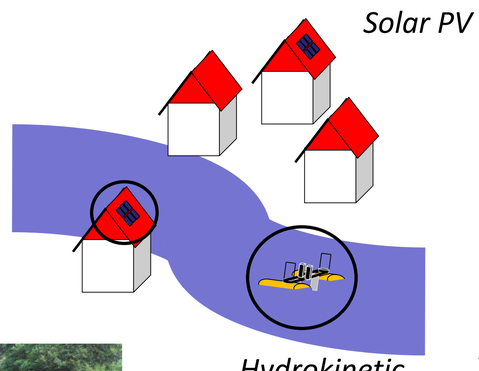
Hydropower contributes already to the renewable power supply of the European power system. But the generation did not increase significantly in the last years (2004-2012 327-335 TWh). Mainly large power plants contribute to the generation. Therefore we want to propose the concept of small hydrokinetic turbines to stimulate a further growth of the Hydropower sector.

Concept

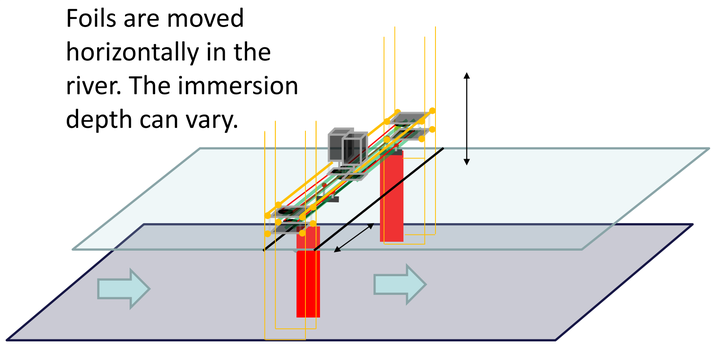
The power consumption of the rural settlements along the Our river in Luxembourg is analysed and estimated by using the German standard load profiles (H0, G1, G2, G4, G5).

In a first step the generation of the oscillating foil turbine is compared to the generation of a commercial hydrokinetic turbine at the same location. Therefore the flow data (depth and velocity) of about 9 years at a measuring station in Luxembourg was analysed.

In a second step the influence of a hybrid system supplying the villages consisting of solar PV and hydrokinetic turbines is analyzed and ist influence on the power system is estimated.



Measurement station at the Our



Concept of the oscillating hydrofoil turbine developed in Luxembourg and Aachen.

Hydrokinetic generation

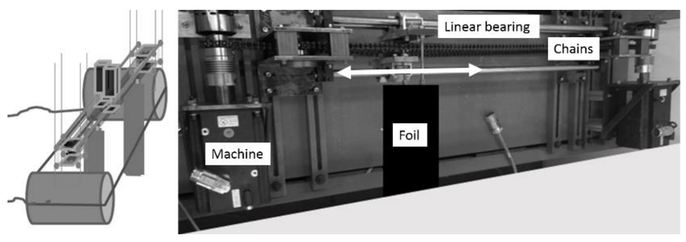
Three different cases of hydrokinetic generation were compared and the turbines performance using the 9 years measurement data was calculated.

1. Oscillating foil turbine operation with a generation >50W – 1117h/a 420 kWh
2. Oscillating foil turbine operation with a generation >200W – 436h/a 304 kWh
3. Operation of an ordinary commercial hydrokinetic turbine when the river is deeper than 2000 mm – 41h/a 80 kWh

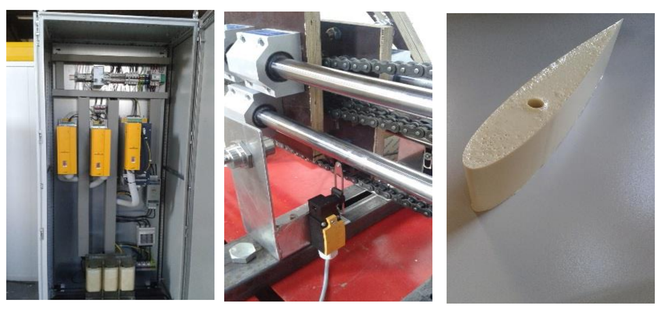
It was seen that the generation varied between 0-4.8kW with the proposed turbines at the proposed location in the Our. The oscillating foil turbine has a size of the foils of 240x36x1000mmwith a platform size of 2500x2500x1500mm (LxWxH). The lab price of it is about 23000€.

The flow conditions of the Our river were the following:
Varying Water level
- Max./Min. 340/48 cm
- Average (9 years) 73 cm

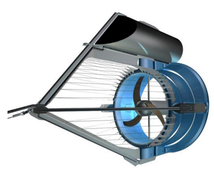
Water velocity
- Max./Min. 2.6/0.2 m/s



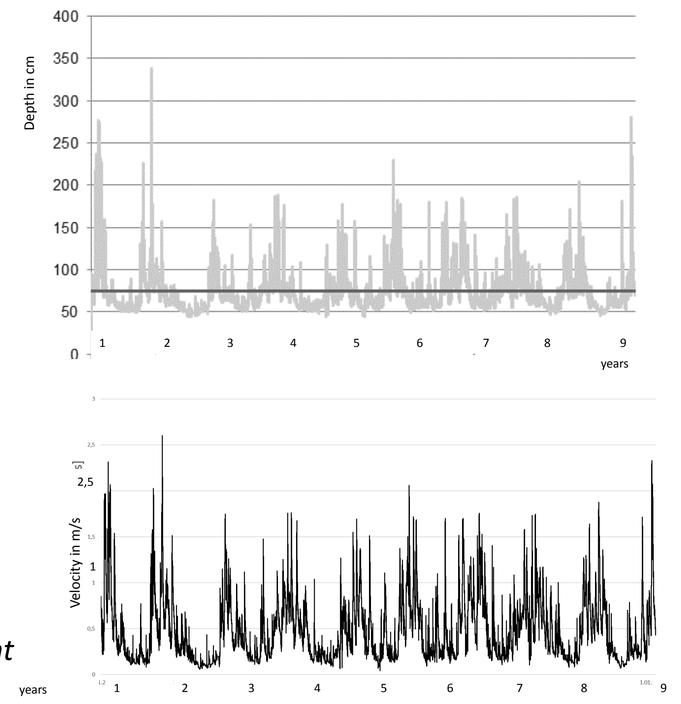
Concept drawing and Lab Setup



Inverter Box, Turbine linear bearings, PUR foil segment



The commercial Smart Hydro hydrokinetic turbine with a minimum immersion depth of 1800 mm.



Depth and velocity of the Our river at the measuring station.

Results

A 100% renewable energy scenario for the villages on the Luxembourgish side of the Our river was analysed. There are 8 settlements with 2409 inhabitants. The annual electricity demand is 4563 MWh.

Using the results from the three cases proposed an unrealistic high number of turbines has to be installed: Case 1 10864, Case 2 15010, Case 3 57037

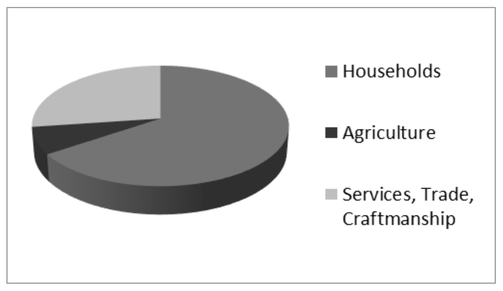
This leads to a turbine distance of 4,75m, 3,44m, 0,9m along the whole river. This is more than unrealistic.

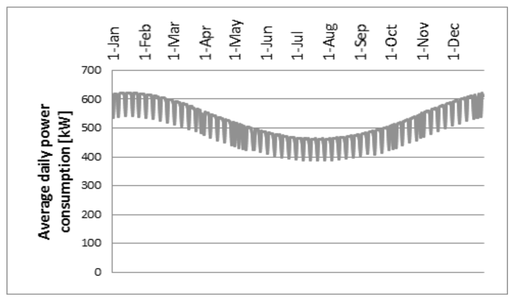
Proposing a solar-hydrokinetic hybrid village power supply the following share of each technology were analysed.

14 kW/person hydrokinetic and a 1,6 kW/person solar system - reduces the energy exchange with the grid to 129 kWh/person/a

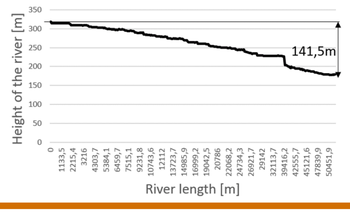
A pure solar supply with 2,3 kW-solar/person - leads to an exchange of 549 kWh/person/a

The hydrokinetic system reduces the energy exchange on about 23% of the former annual exchange.





Share of different Consumer and the annual load curve, based on standard load profiles. Map of the Our river and height profile.



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