Modular Hydrokinetic Micro Generation

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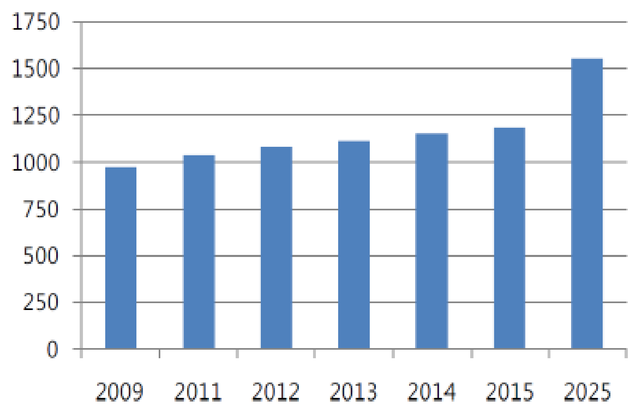
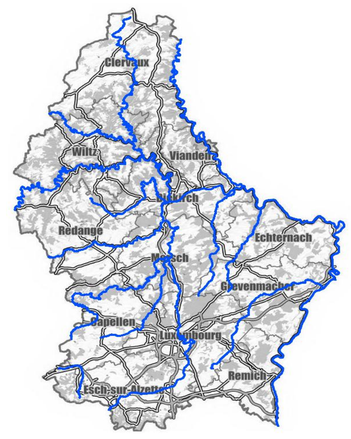
Motivation and Potential in Luxembourg

- 16/27 of the kinetic energy is useable (Betz-factor)
- 175 GWh/a technical potential of hydropower
- 103 GWh Betz-factor restricted
- 52,5 GWh for an efficiency of 30% (5,9 MW p.a.)
- 86,78 GWh national wind and Solargeneration in 2011
- River hydropower generation 88,27 MW/Mio. Pers. (Germany 54,67 MW/Mio. pers.)



Electricity Consumption in Luxembourg and scenarios until 2025 in MW (Gouvernement du Luxembourg 2010).



Rivers in Luxembourg (Gestion de l'eau Luxembourg).

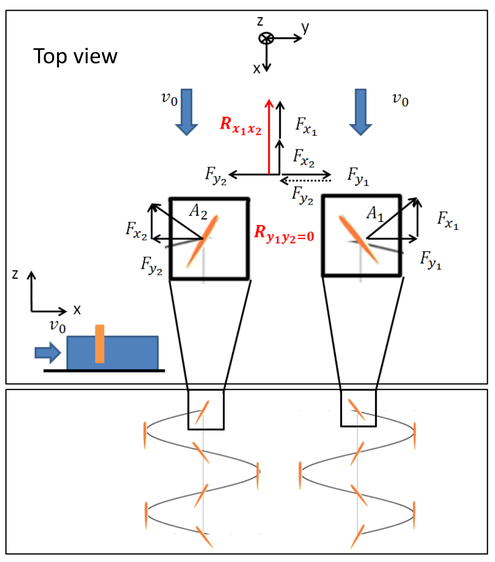
Moselle	37
Gander or Altbach	17
Syre	30
Sûre	160
Wiltz	35
Clerf or Woltz	45
Blees	14
Our	51
Ernz blanche	30
Ernz noire	25
Alzette	60
Mess	11
Kayl	7
Dudelingerbach	7
Pétrusse	11
Mamer	25
Eisch	28
Attert	32
Wark	19
River system of the Meuse	
Chiers	15

Length of the rivers in Luxembourg in km (Gestion de l'eau, Luxembourg).

Mechanical Concept

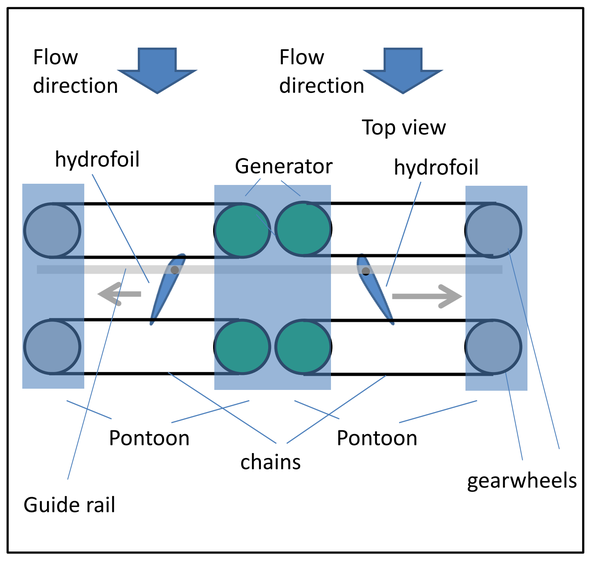
- Two vertical hydrofoils move horizontally in a river
- The inverse motion of both foils damps the influence of disturbing forces
- Vertical setup allows:
  - Adaption to water depths
  - Simple removal of flotsam
  - Simple maintenance of the mechanism

Forces and moving principle



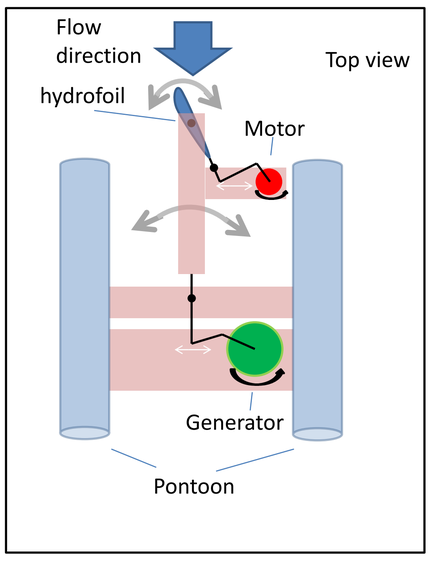
Forces and moving principle tandem foil (Norta).

Concept I



Mechanical concept I (Norta).

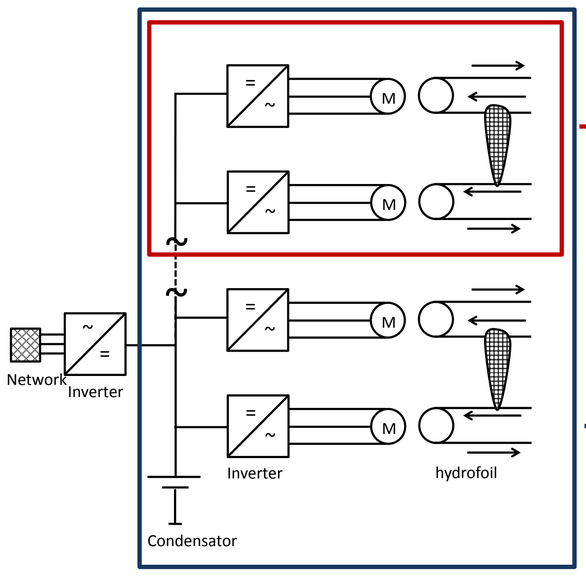
Concept II



Mechanical concept II (Norta).

Electrical concept

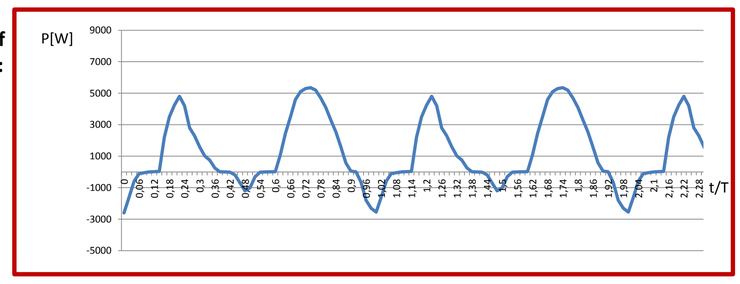
- Experimental data (Université Laval) for sinusoidal motion leads to an alternating generation and consumption of electricity. An average positive generation of 1,3 kW (min. -2,6 kW max. 5,3 kW) for a flow speed of 2m/s, 2 NACA foils (180 degree phase shifted) of 164 cm x 24 cm (blue graph)
- The combination of three phase shifted generation profile-pairs lead to an in average positive generation of 3,7 kW (min. 0,3 kW max. 8,1 kW), for a flow speed of 2m/s, 3 x 2 NACA foils of 164 cm x 24 cm (red graph)
- The modular concept includes a condensator to damp the fluctuation in the generation and can include more hydrofoil pairs
- The chain concept can include several foils per chain



Electrical concept n-phase shifted foils (Norta).

Number of hydrofoils:

1 phase shifted pair

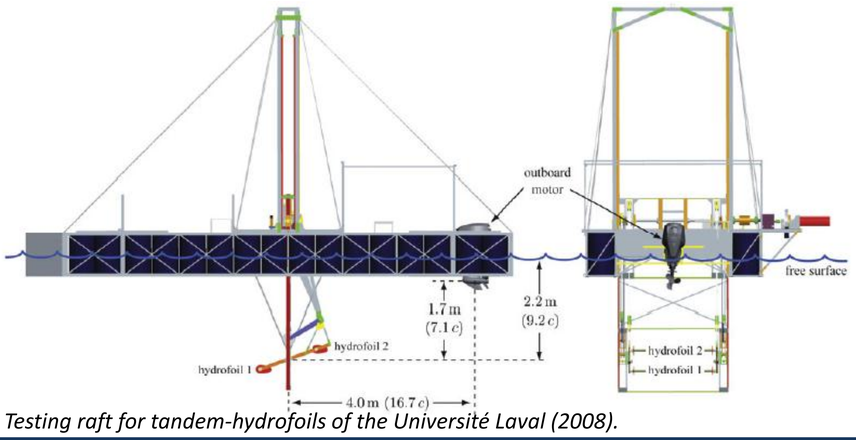


3 phase shifted pairs

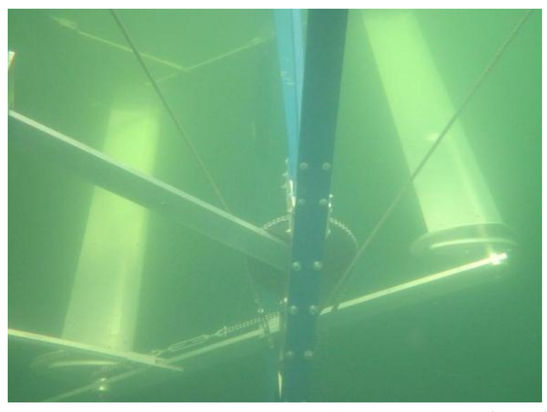
Performance single foil (blue) and of three phase shifted foils (0/0,22/0,44 T) (red).

Inspiration and existing systems
(from the Université Laval Kinsey/Dumas/Dêschenes, Canada)

- Single hydrofoil efficiency 20% (f=0,83),
- Dual hydrofoil efficiency 30% (f=0,92), inter-wing length 1,3 m, amplitude 0,62m
- Raft mass 2000kg
- Tested in a lake in Canada
- Simulation of the motion with ANSYS Fluent



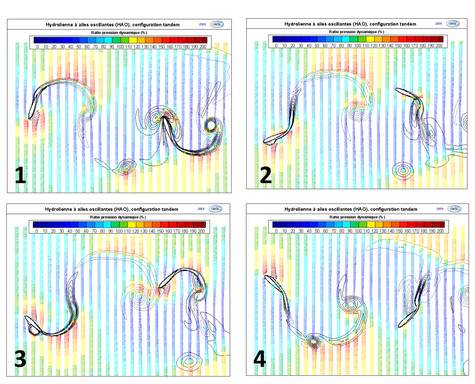
Testing raft for tandem-hydrofoils of the Université Laval (2008).



View on tandem-hydrofoils of the Université Laval (2008).

Next steps

ANSYSY Fluent Simulation:
- Testing motion speed
- Testing time dependant angle of incidence
- Testing different profiles
- Develop optimization: Efficiency, Max. power
- Test performance of controllability



ANSYS Fluent simulation of the tandem Hydrofoil (Université Laval).

Lab setup in Netpower DemoLab
- Test motion of the foils
- Test performance of generators
- Test several foils per chain
- Measure losses of mechanics
- Install sample setup for field test

NetPower DemoLab Université du Luxembourg.

Field test at the locations of SEO
(Société Électrique de l'Our)
- Test technology on a weir
- Test performance in open flow
- Include advice of experienced staff
- Feed in in Luxembourgish grid
- Longer field test over several days

Turbine test location of the SEO.

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