Small nomadic counter-rotating wind turbine : design and experimentation

Florian Huet, Emile Roux, Aurélien Carré

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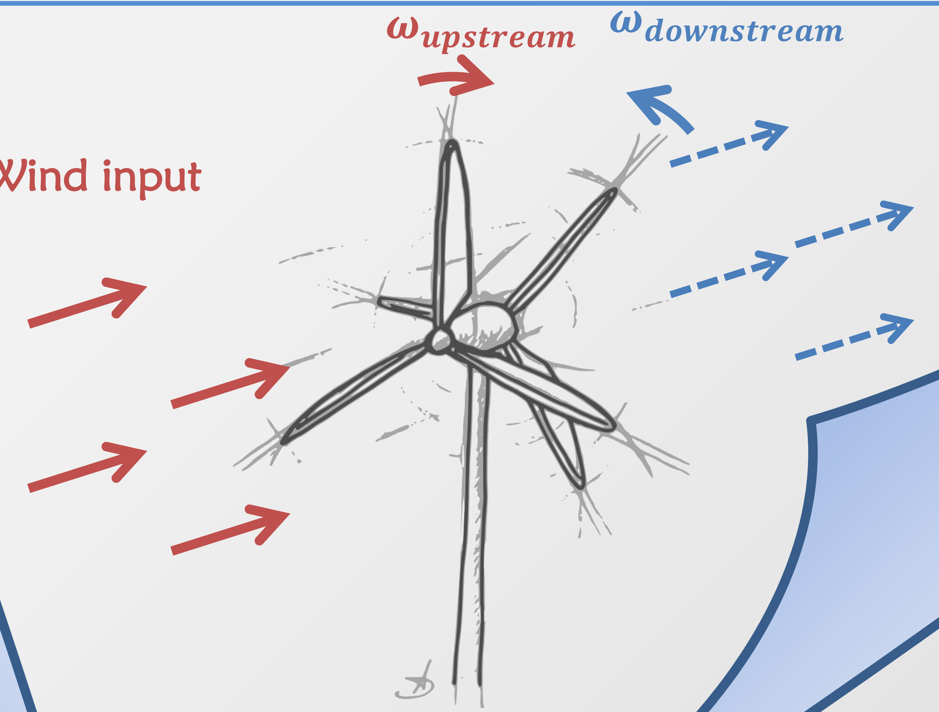
Counter-rotating Wind Turbine Concept

Target : Develop a new high efficiency small scale wind turbine generator providing a power of a few Watts power

Application : Recharge low capacity batteries (Smartphone, GPS, lamp…)

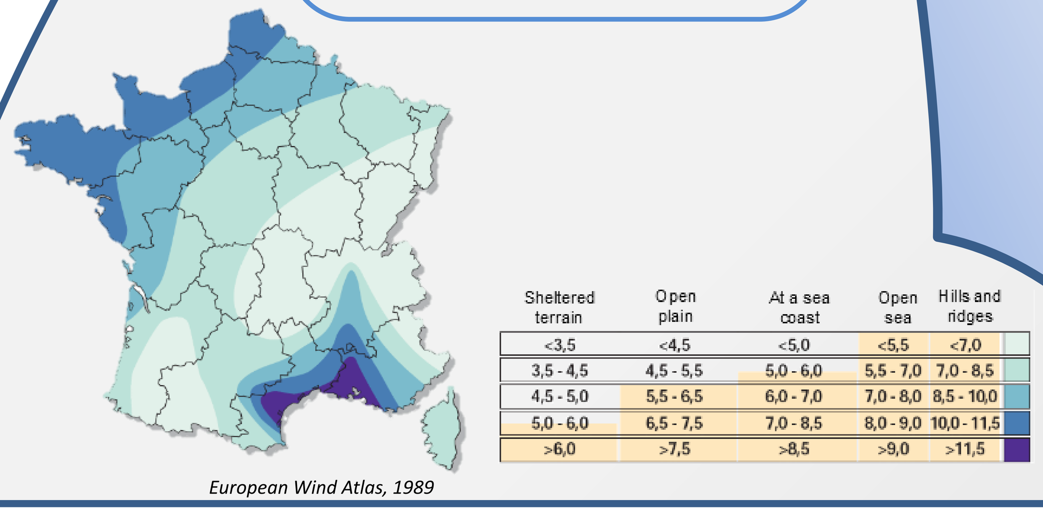


Wind Source

Natural Wind :

- $V_{mean} = 3{,}9\ m.s^{-1}$
- $V_{dominant} = 5\ m.s^{-1}$

Relative Motion



Propellers Design

Heliciel : Design of two optimized propellers stages function of :

- Wind input, Rotation output
- Global geometrical conditions
- Aerodynamic profiles, Pitch angle
- Blades number

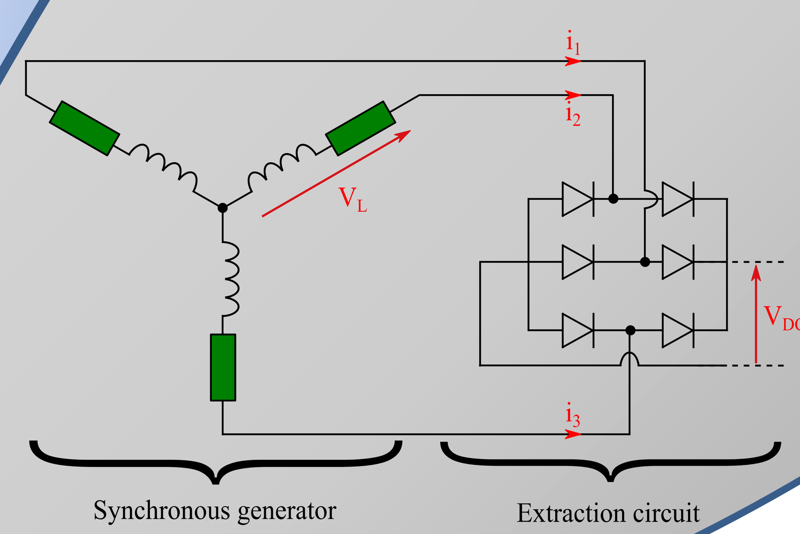
Goal : Maximize the mechanical power output

Electromechanical Conversion

Generator : Synchronous three-phases electric generator with permanent magnets

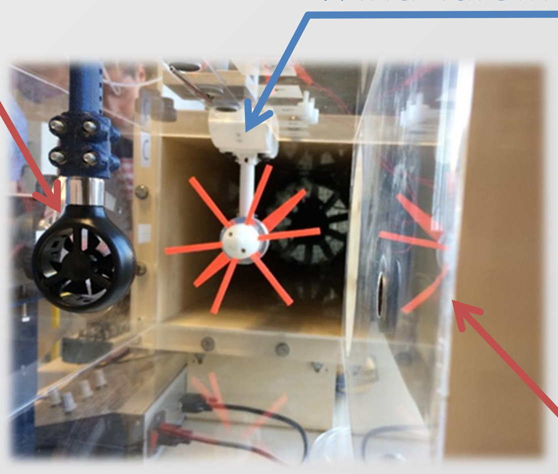
Extraction Circuit : three-phases bridge rectifier

$$V_{DC} = \frac{3\sqrt{2}}{\pi} V_L$$



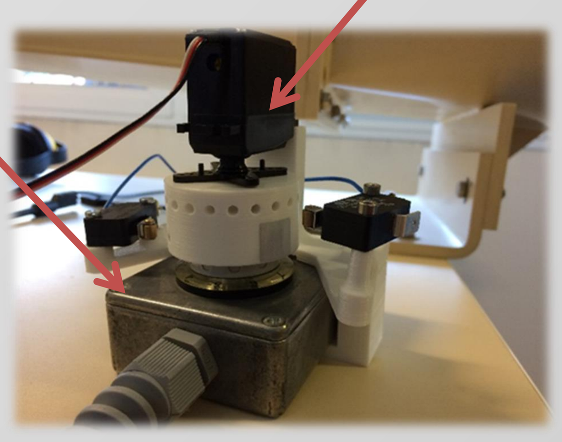
Experimental Setup

MATLAB NATIONAL INSTRUMENTS

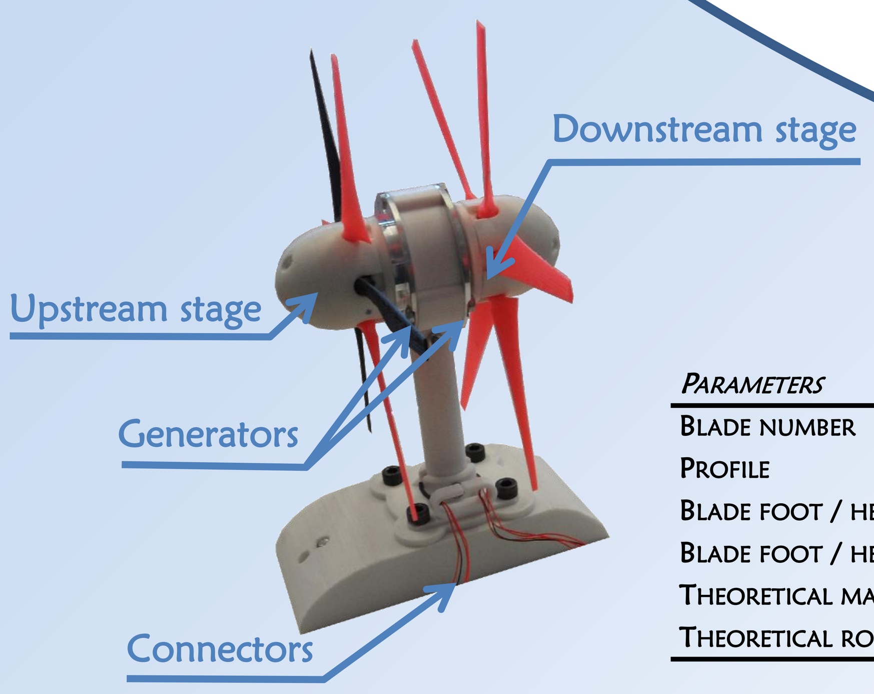


Wind Tunnel :

- Section 23 x 23 cm²
- $V_{max} = 45\ m.s^{-1}$
- Closed loop controlled flow



Energy Harvesting



Parameters	Propeller Stage Upstream	Propeller Stage Downstream
Blade number	6	6
Profile	NACA1412	NACA6412
Blade foot / head diameter	40 mm / 180 mm	
Blade foot / head width	17 mm / 7 mm	17 mm / 17 mm
Theoretical maximum power	0.8 W	2.2 W
Theoretical rotation velocity	2800 rpm	6000 rpm

Theoretical Maximum Wind Power :

$$P_{max\_th} = \frac{16}{27} P_{kinetic} = \frac{8}{27} \rho S v^3$$

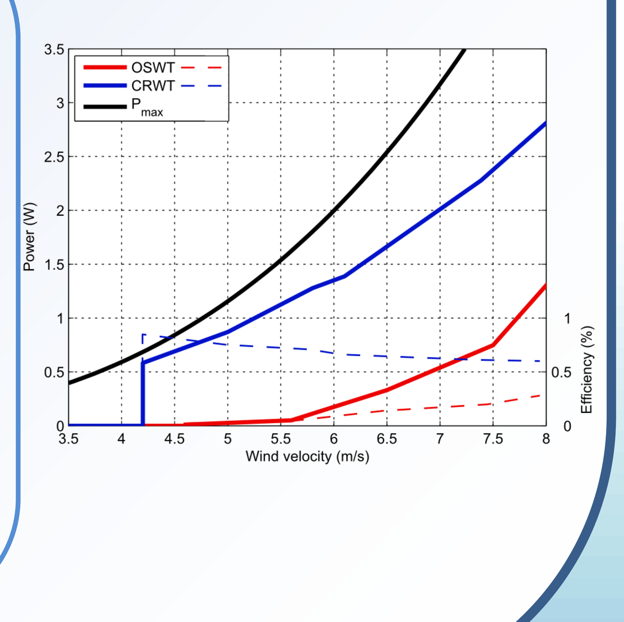
One Stage Wind Turbine (OSWT) :

$P_{OSWT} = 0$ W at 4,2 $m.s^{-1}$, 1.3 W at 8 $m.s^{-1}$

Counter-rotating Wind Turbine (CRWT) :

$P_{CRWT} = 0.6$ W at 4,2 $m.s^{-1}$, 2.8 W at 8 $m.s^{-1}$

Maximum efficiency 85 % at 4,2 $m.s^{-1}$



Conclusions Prospects

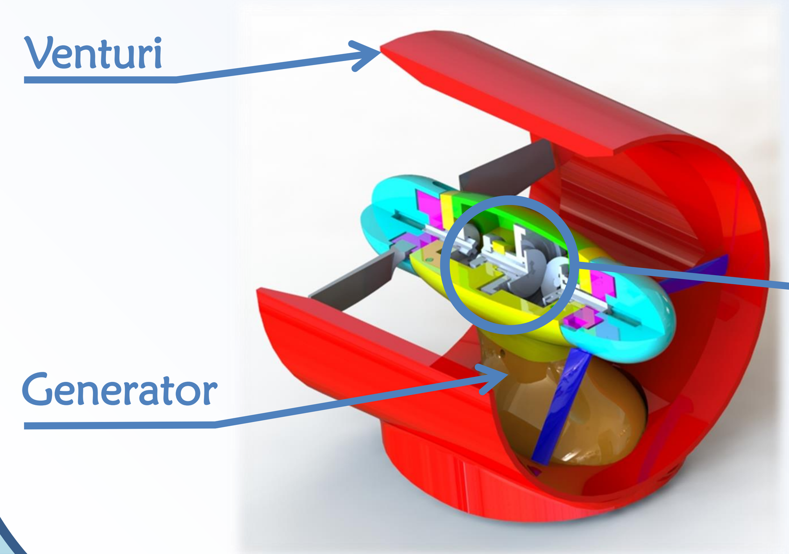
First Promising Results : Higher efficiency than standards small scale wind turbine (~30 %)

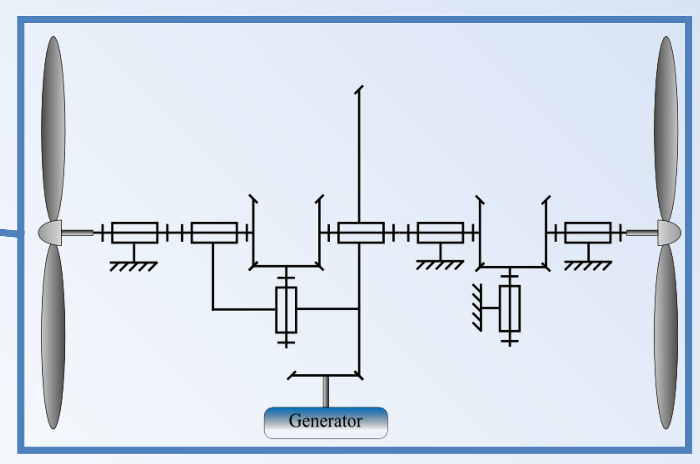
Propellers Optimization : The first prototype allows to test various propeller geometries

Next Prototype

Increase Locally The Speed : Integrate a venturi into the prototype to increase wind speed and concentrate the air flow

Improve The Transmission : Use a single generator while separating both stages thanks to a mechanical differential





Optimized Differential Transmission

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