



## Small nomadic counter-rotating wind turbine: design and experimentation

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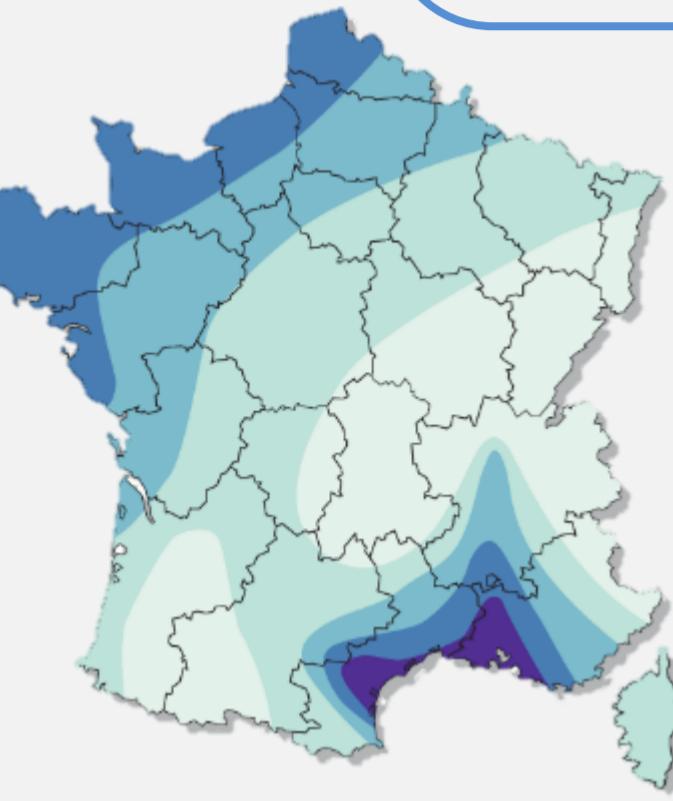
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Wind  
Source



Natural Wind :

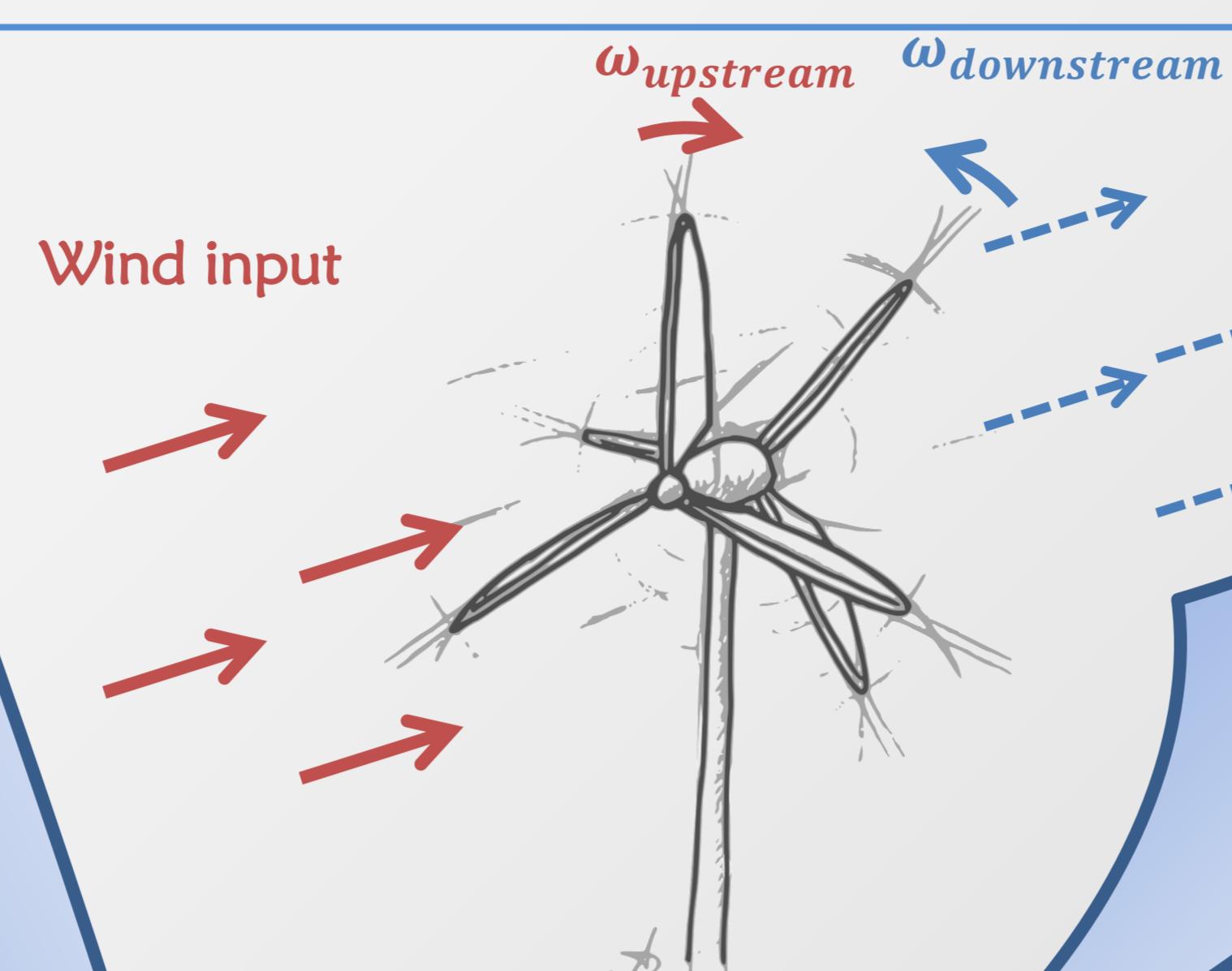
- $V_{\text{mean}} = 3.9 \text{ m.s}^{-1}$
- $V_{\text{dominant}} = 5 \text{ m.s}^{-1}$

Relative Motion

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...)



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



## Small nomadic counter-rotating wind turbine : Design and experimentation

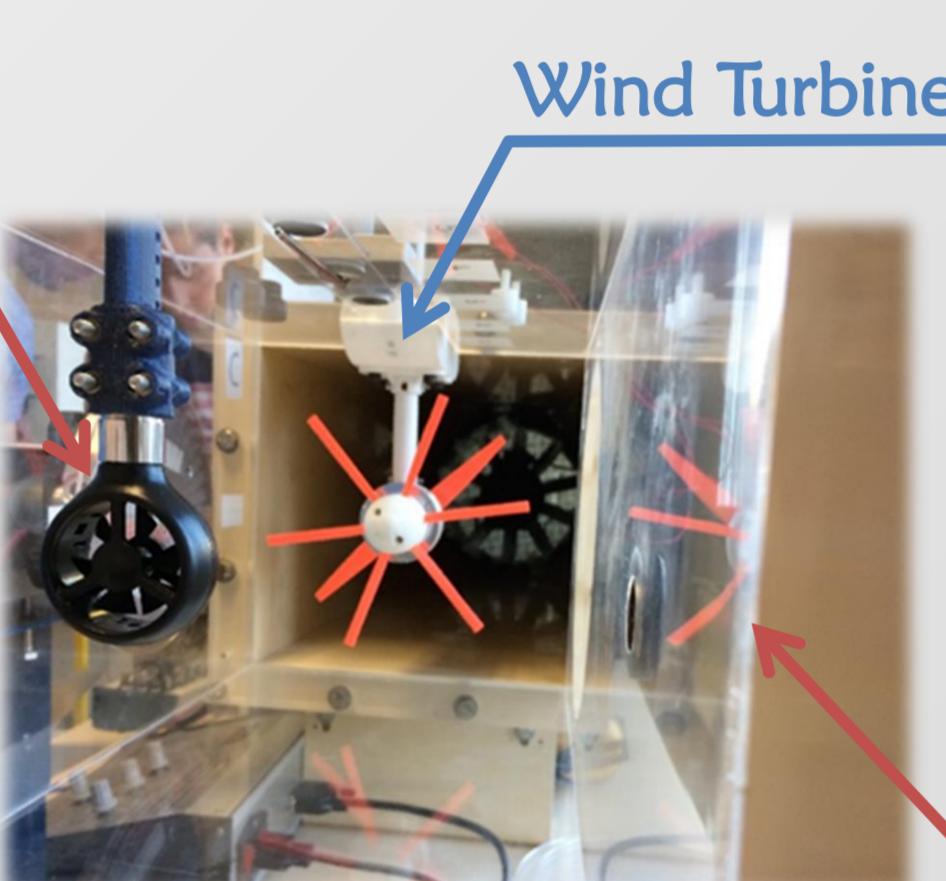
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MATLAB

NATIONAL INSTRUMENTS

Experimental  
Setup



Wind Tunnel :

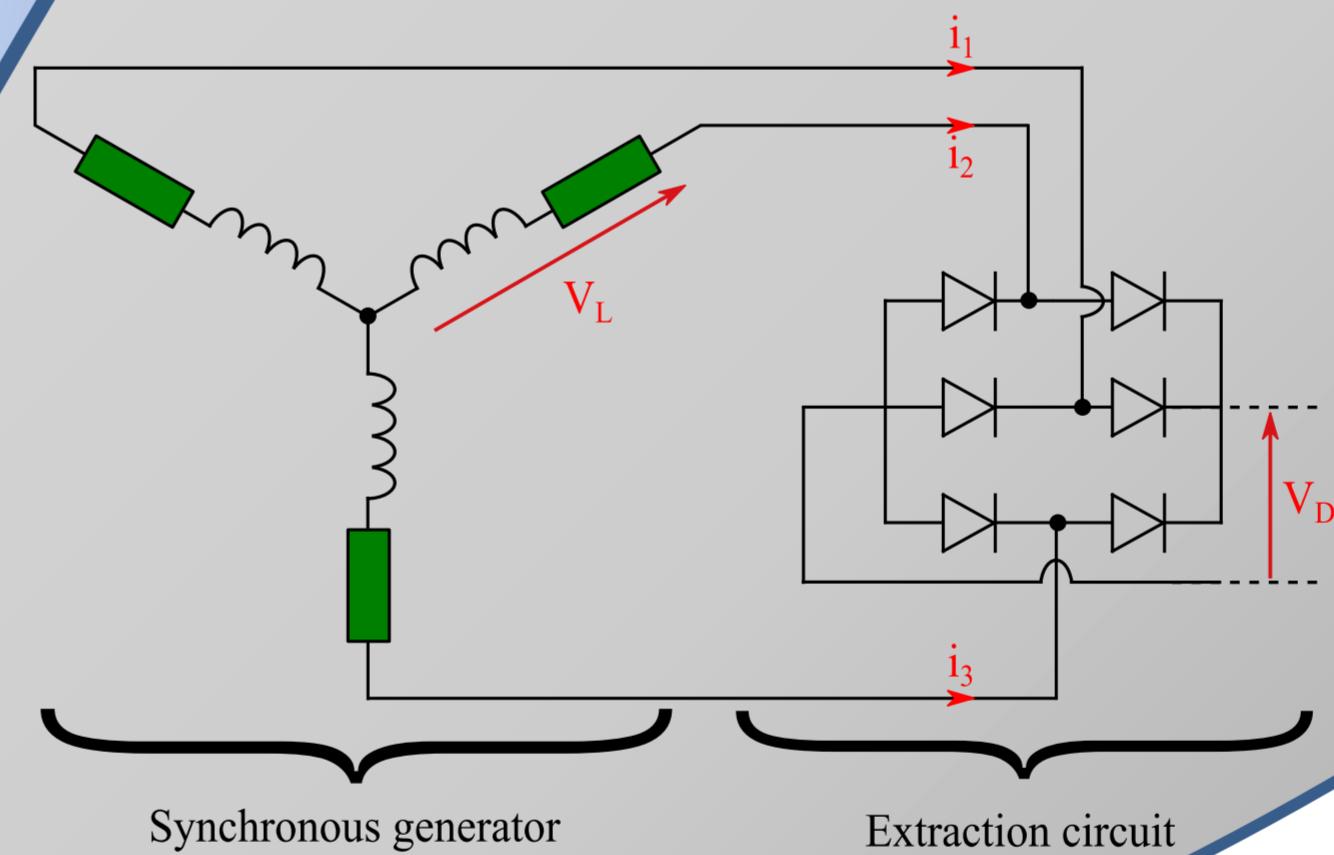
- Section  $23 \times 23 \text{ cm}^2$
- $V_{\text{max}} = 45 \text{ m.s}^{-1}$
- Closed loop controlled flow

Electromechanical  
Conversion

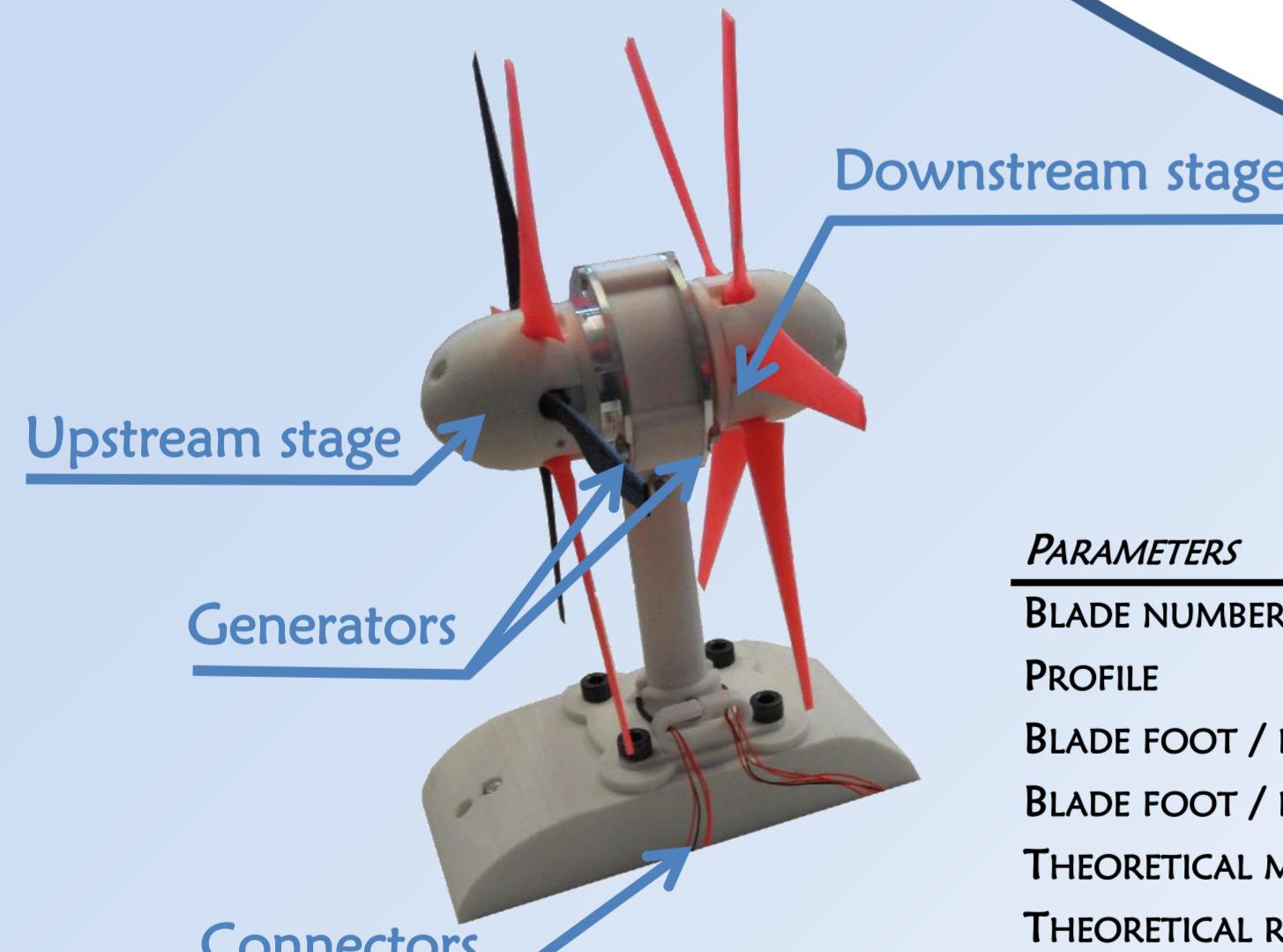
Generator : Synchronous three-phases electric generator with permanent magnets

Extraction Circuit : three-phases bridge rectifier

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



Energy  
Harvesting



PARAMETERS	PROPELLER STAGE	
	UPSTREAM	DOWNTREAM
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 :

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

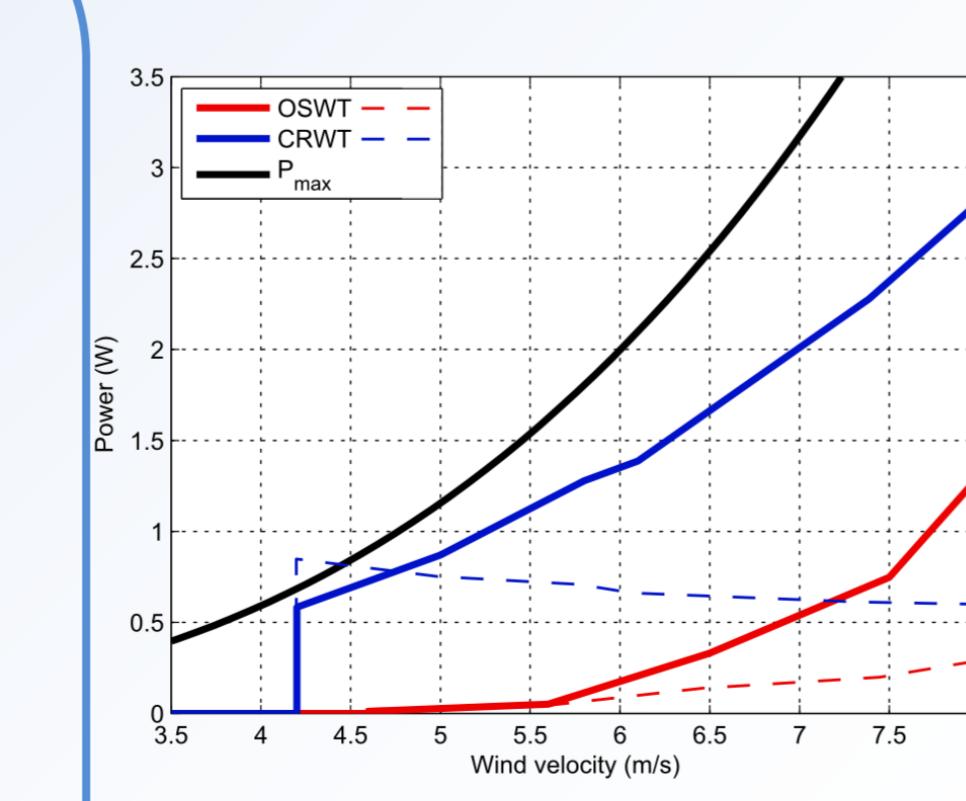
One Stage Wind Turbine (OSWT) :

$$P_{\text{OSWT}} = 0 \text{ W at } 4.2 \text{ m.s}^{-1}, 1.3 \text{ W at } 8 \text{ m.s}^{-1}$$

Counter-rotating Wind Turbine (CRWT) :

$$P_{\text{CRWT}} = 0.6 \text{ W at } 4.2 \text{ m.s}^{-1}, 2.8 \text{ W at } 8 \text{ m.s}^{-1}$$

Maximum efficiency 85 % at 4.2 m.s<sup>-1</sup>



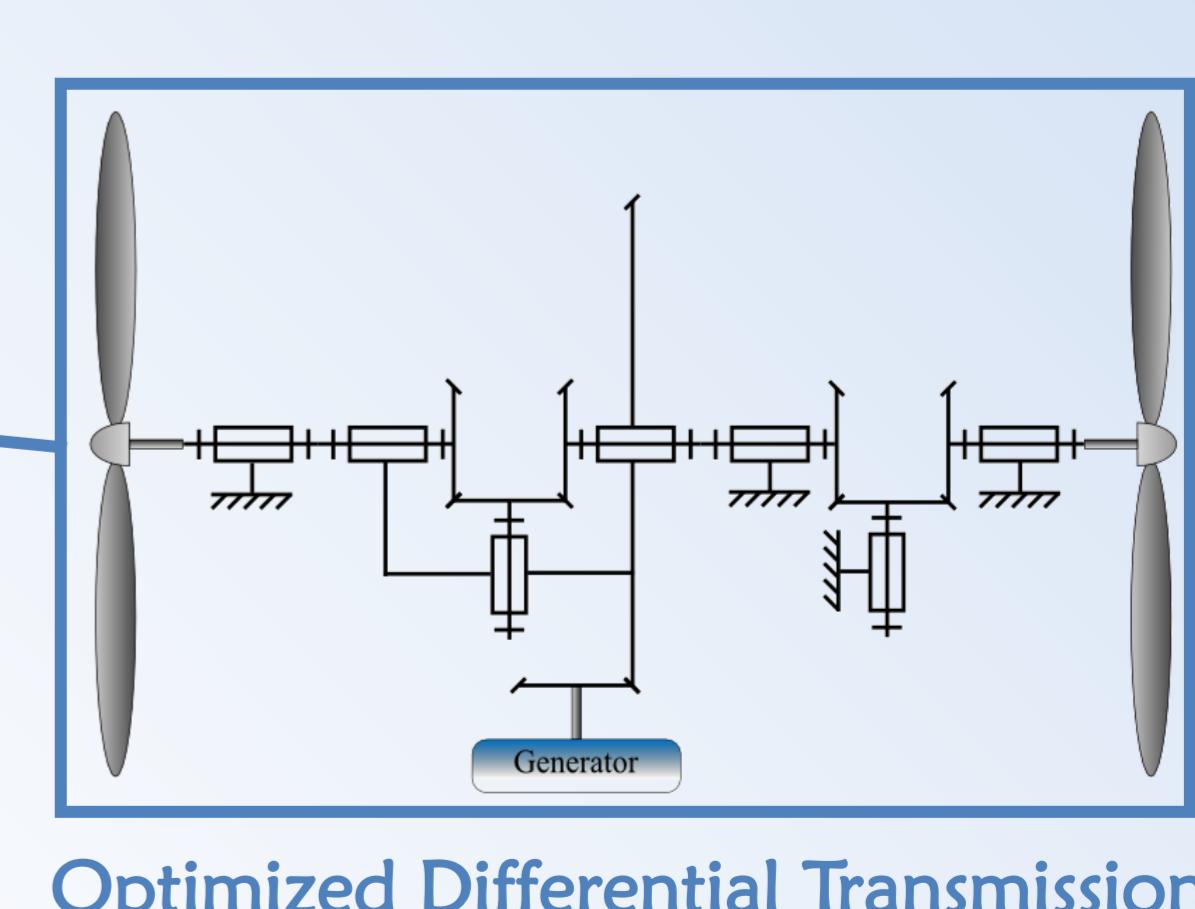
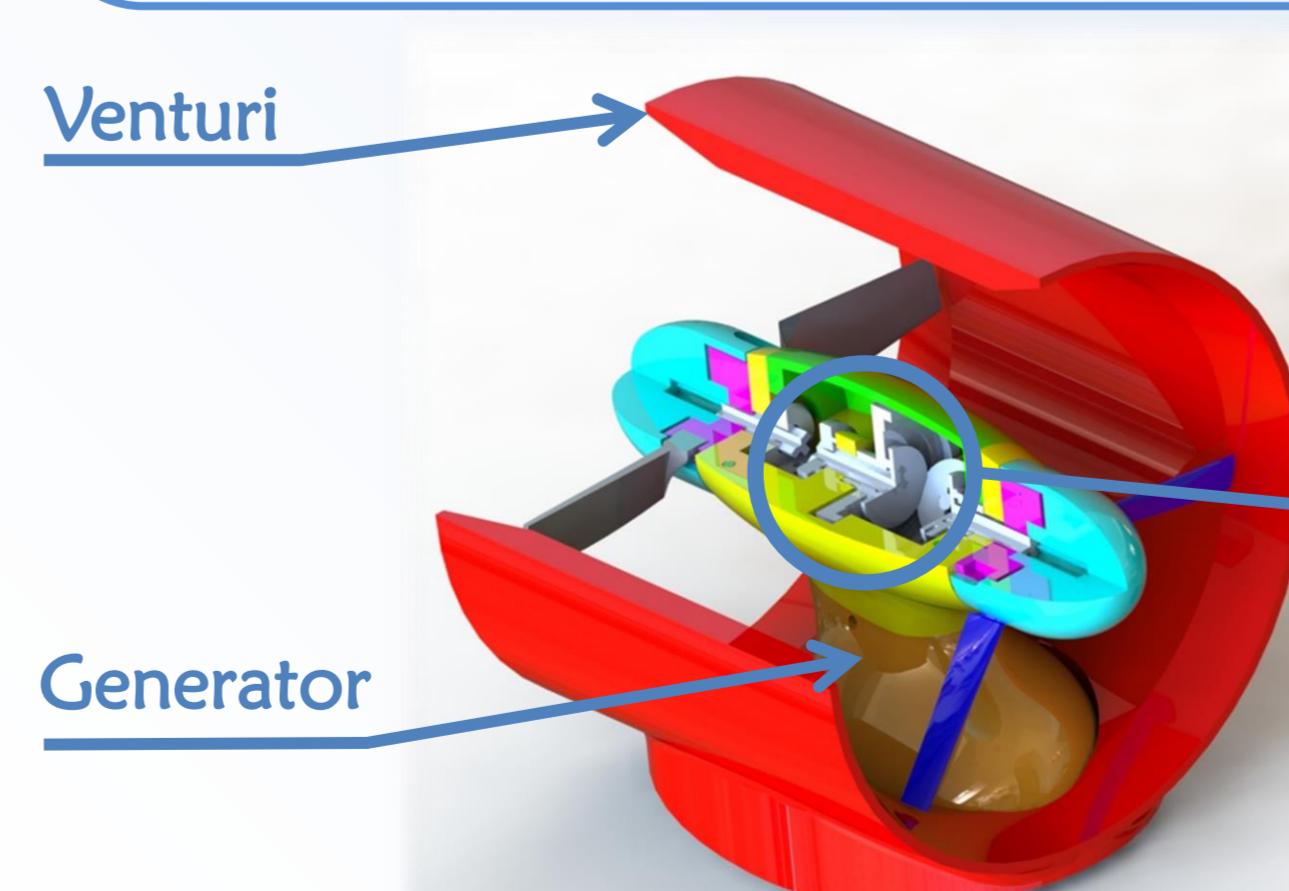
First Promising Results : Higher efficiency than standards small scale wind turbine (~30 %)

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



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