

# CONVERGENT-DIFFUSER FOR SMALL HORIZONTAL WIND TURBINES

Luís Frólén Ribeiro<sup>1</sup>, Jorge Paulo, Valdemar Garcia  
1frolen@ipb.pt

## Introduction

A small horizontal axis wind turbine (HAWT) equipped with an annular Convergent-Diffuser (C-D) is under development.

Small to medium wind turbines equipped solely with a diffuser are becoming quite common: the annular structure around the rotor decreases the pressure downstream the rotor, augmenting the air velocity and power output. It also may replace the wind vane. Previous studies for such designs, for instance Ohya, Y. 2010, report a maximum increase in power output up to 150%.

We present the preliminary results of an alternative design for a convergent-divergent annular structure that involves the rotor. This structure was optimized in CFD-simulations and 2 models were built for wind tunnel measurements.

The maximum power output obtained was 187% higher than the case for a rotor without the C-D structure.

Field tests are undergoing at this moment for a C-D adapted in model Rutland 913 Windcharger of 90 W.

## Materials and Methods

### Wind Turbine and C-D characteristics

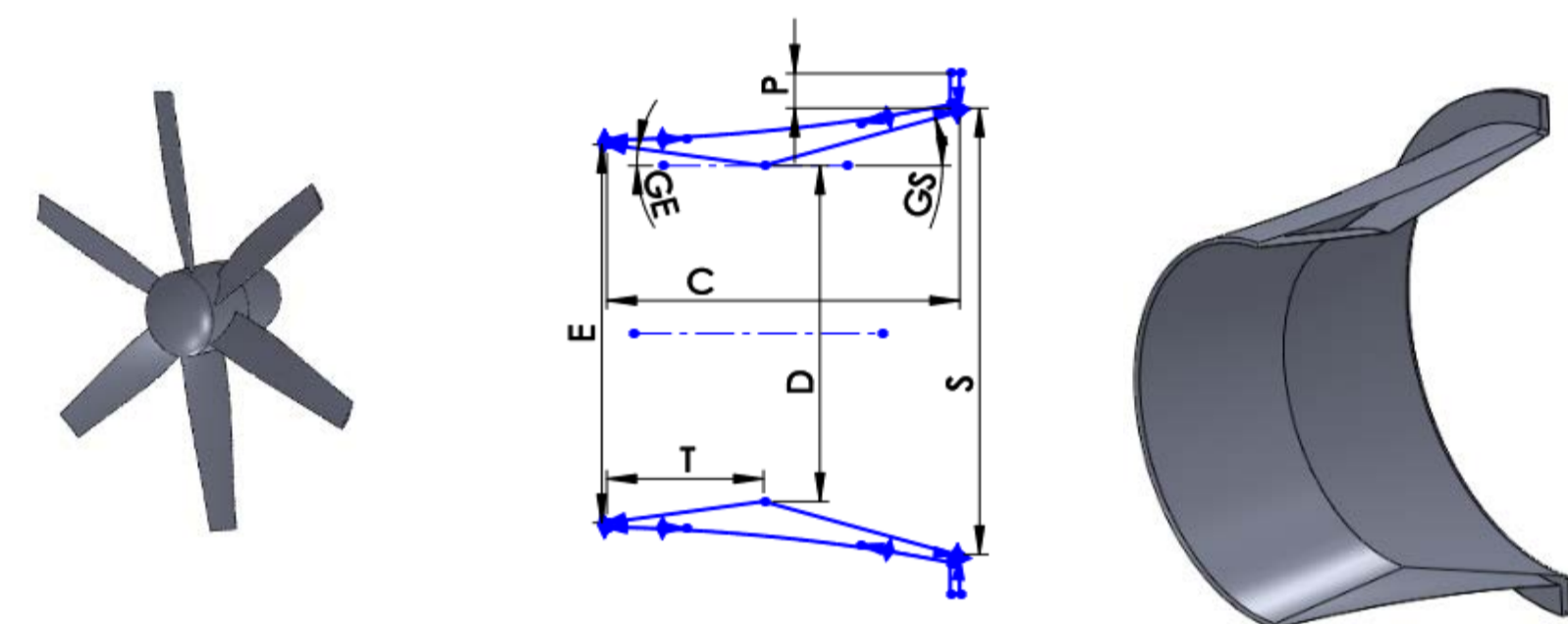


Fig. 1 - Prototype of the wind rotor based in the Blade Element Theory projected in SolidWorks®. The C-D was also design and tested in the same environment.

A total of 21 types of simulations were performed (3 P against 7 different geometries (table 1). The models that yielded the best performance were models 1 and 2.

Table 1 – Seven C-D configurations where tested in SolidWorks®. The arrangements that where more efficient are highlighted.

Model	GE (%)	GS (%)
	7	9
	7	15
<b>1</b>	<b>8</b>	<b>16</b>
	9	14
	10	10
	14	14
<b>2</b>	<b>14</b>	<b>18</b>

### Wind turbine and C-D scaled prototypes

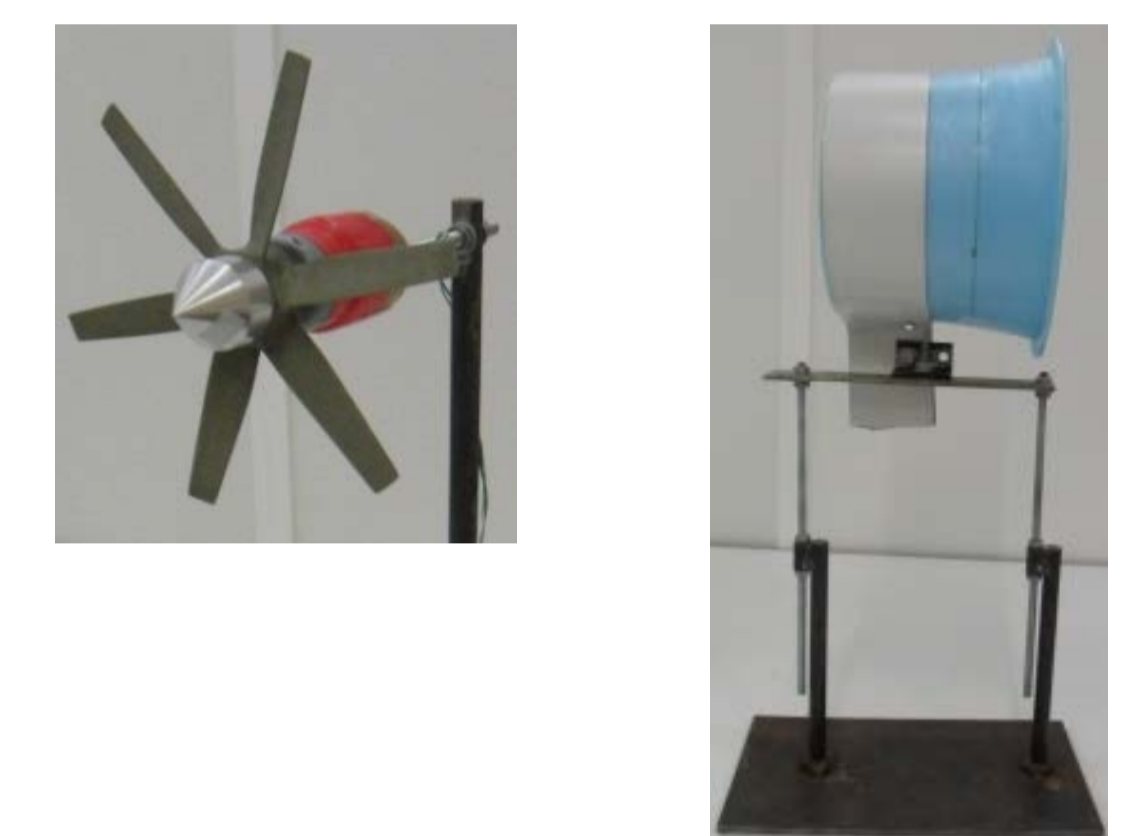


Fig. 2 – Final prototype of C-D model 2.

## Results and discussion

### Wind turbine with C-D

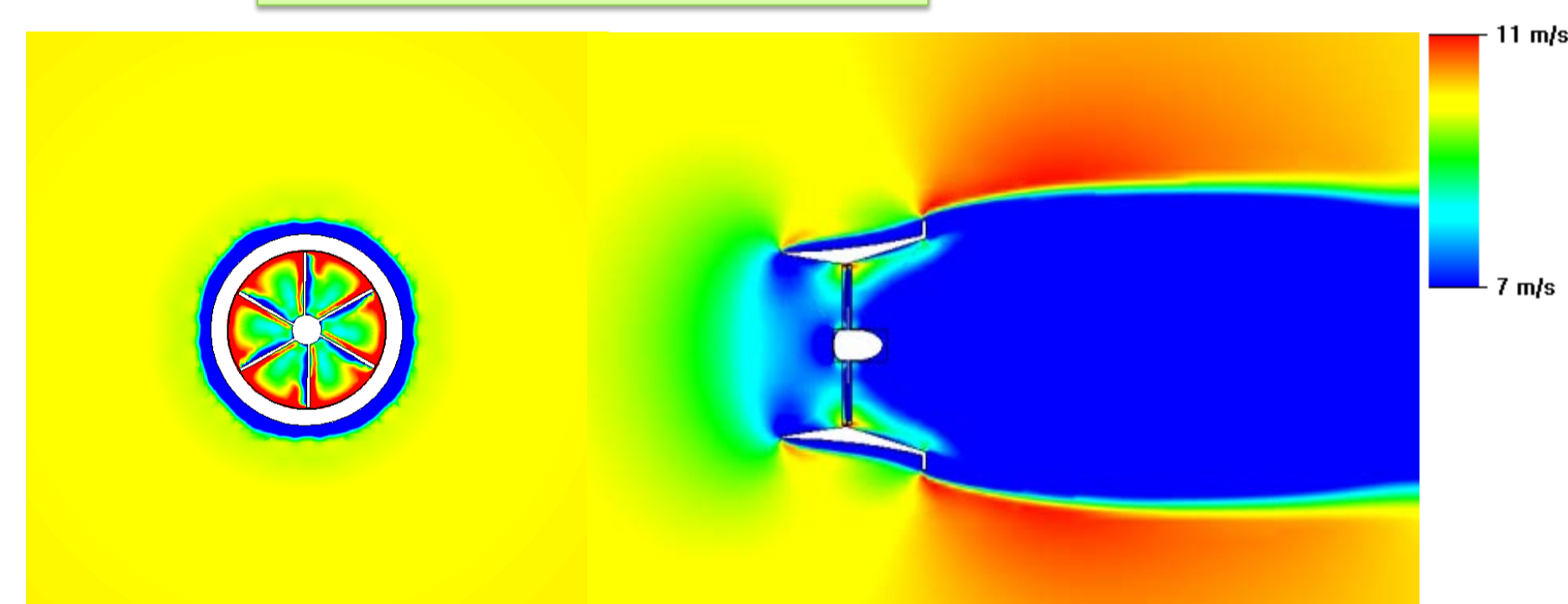


Fig. 3 – Rear and lateral views of the wind velocity field inside and around the C-D.

### Without C-D

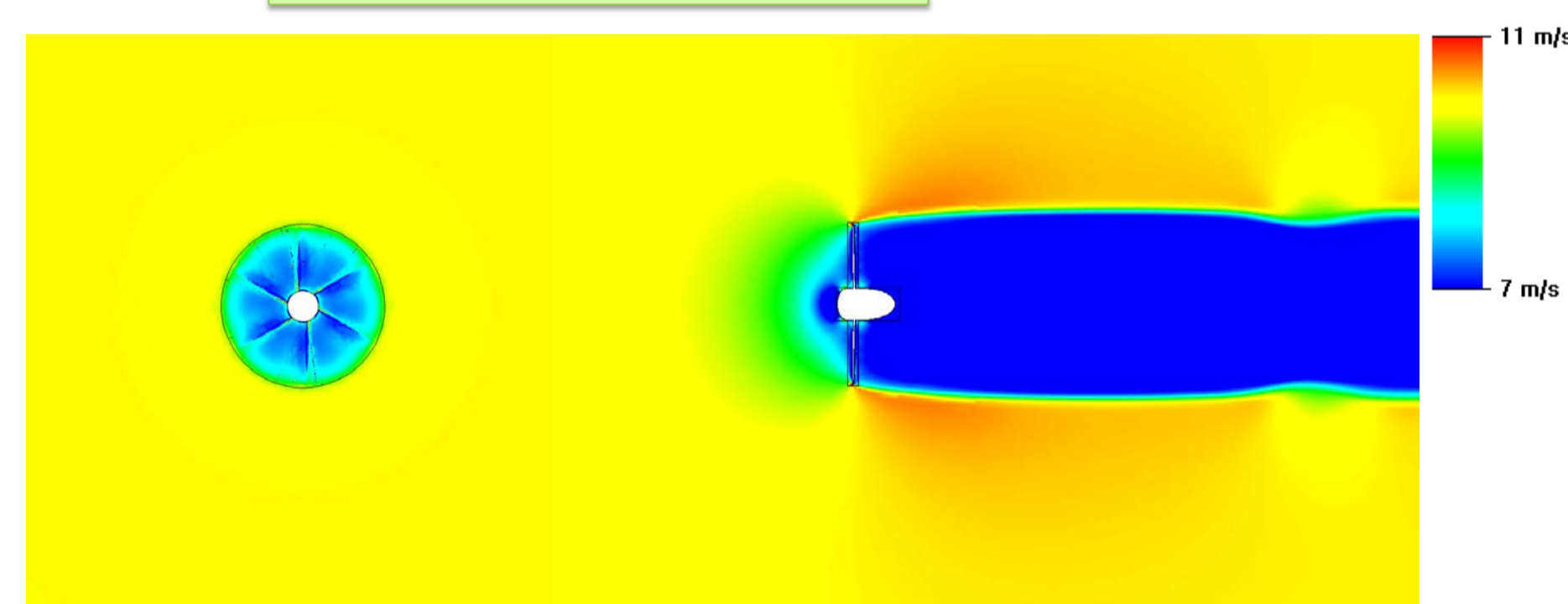


Fig. 4 - Rear and lateral views of the wind flow field around the HAWT without the C-D.

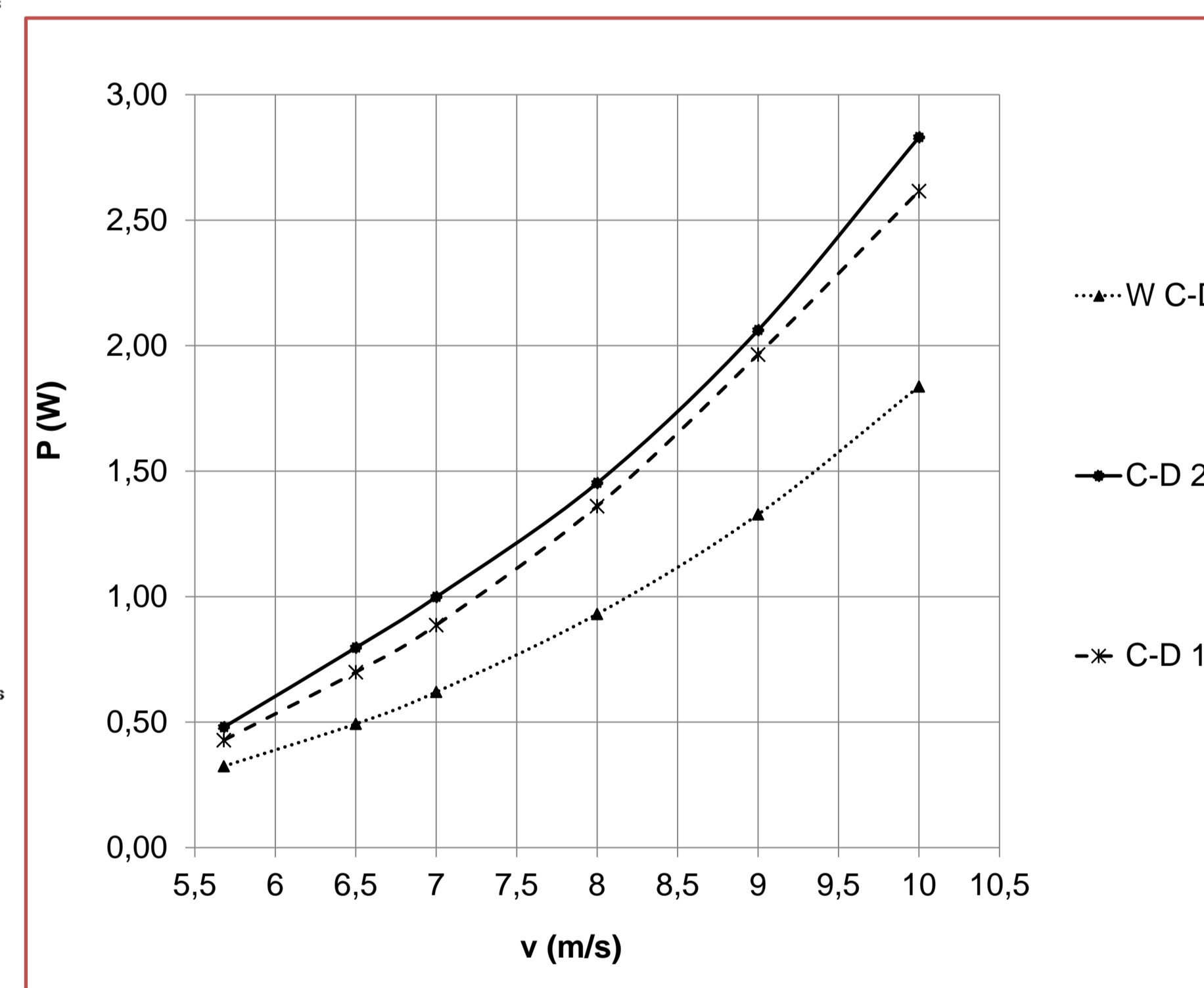


Fig. 5 - Power output results obtained from SolidWorks® for 2 different C-D configurations: models C-D 1 and C-D 2. The simple rotor case W C-D is the reference.

### Wind tunnel setup

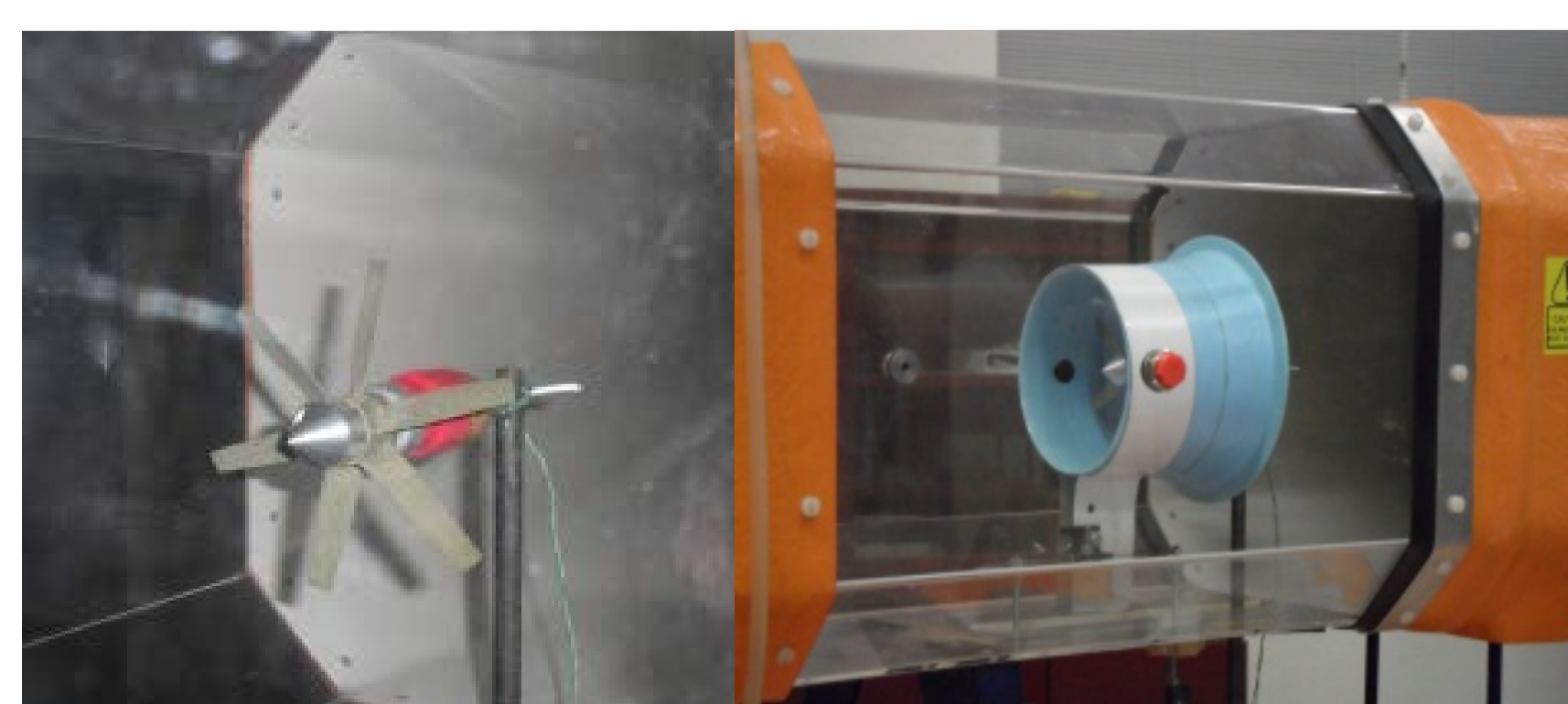


Fig. 6- Wind tunnel setup without and with the C-D.

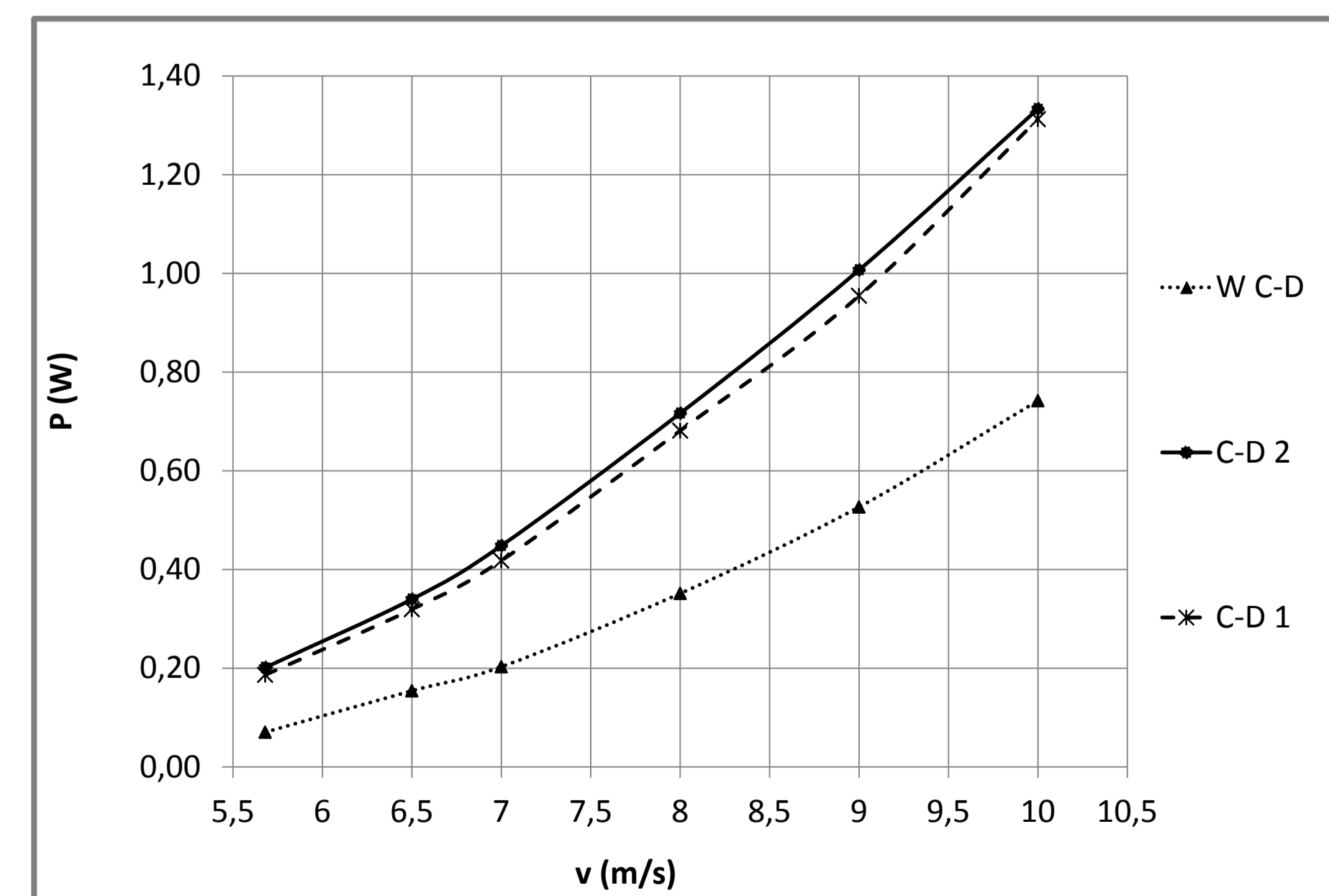


Fig. 7 - Power output measured for 2 different C-D configurations: models C-D 1 and C-D 2. The simple rotor case W C-D is the reference.

## Conclusions

The mean measured increase in power output with the C-D was 124%. The value is in the same order of magnitude of simple diffusers results published by [1] and [2].

The mean measured power output with the C-D against the W C-D case was 43% higher than the mean simulated power output for the same comparison, i.e. the simulations underestimate the increase in power output.

An HAWT (90 W power output) is undergoing field measurements at the present moment, figure 8.

## References

- [1] Y. Ohya e T. Karasudani, "A Shrouded Wind Turbine Generating High Output Power with Wind-lens Technology," Kasuga, Japan, 2010
- [2] T. Matsushima, S. Takagi e S. Muroyama, "Characteristics of a highly efficient propeller type small wind turbine with a diffuser," Tokyo, Japan, 2005.
- [3] H. Grassmann, F. Bey, G. Cabras, M. Ceschia, D. Cobai e C. DelPapa, "A partially static turbine - first experimental results," Elsevier Science, 2002

Fig. 8 – 3D wind turbine field set-up that is current being at field tests.