REPORT OF PILOT PROJECT ARDOOIE

Location description

The Rysselende Mill, Brugsesteenweg 2 in 8850 Ardooie

Why Ardooie? The combination between the history of the site and its future is a nice touch. Furthermore, the presence of many passers-by and, of course, the restaurant where it is possible to relax or meet while charging.

- Rysselende Molen : Restaurant, Lodging & Charging Station
- Parking accessible 7/7, restaurant open 7/7 (closed on Wednesdays in winter) = charging & lunch
- Ardooie = heart of West Flanders entrepreneurs, impactful (family) businesses nearby - investors with vision for the future & farmers with large areas à solar panels and co
- Strong landmark due to historical building, located on the corner of several important traffic axes
- Energy- & water-neutral catering business, total concept water - electricity - wind energy - storage - consumption - sale of fast chargers - trading
- Transparent, low-threshold test case (people can come and see the effective operation and results without having to make themselves known)
- Ambition to use the accessible & recognisable site to demonstrate the energy products of the future and their concrete impact
- Unite an old, historical energy producer with the newest on 1 site

INSTALLATION SETUP

This project tested the different types of Aeroleaf® ® mini wind turbines (MWT), a total of 12, and various generators: 200W-200RPM, 300W-850RPM, 500W-350RPM, 100W-600RPM and 3000W-1200RPM. To fully harvest energy, 2 types of solar panels were also installed. Namely, there are 920 solar and 2600 wind hours (the wind turbines also generate energy at night). Both energy systems are coupled to a 4.6KWh Polytech battery (scalable if necessary) to be then switched to a Victron inverter. The inverter is linked to the high-voltage cabin installation. Communication is via a Victron Cerbo GX programmable as per own requirements. Everything was mounted on a green powder-coated support structure, specially tailored for the high-voltage cabin. Finally, an anemometer was mounted to log wind speeds up to 60,000 data. The objective is to compensate for the 3KWh loss current of the existing infrasturcture.

Aeroleaf® ®

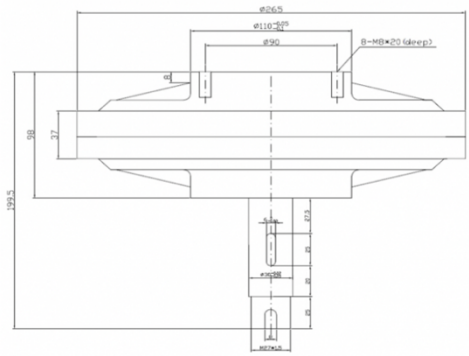
Aeroleaf® ®

The Aeroleaf® ® is a patented micro wind turbine consisting of a double blade with a vertical axis in the shape of a blade and a synchronous microgenerator with permanent magnets that delivers peak power of 200, 300 , 500, 1000 or 3000 Wp from 200 min-1 There are 2 versions whose blades are made of recyclable ABS plastic or aluminium. The alumiunium version, model X, can be customised according to the desired yields and colour. Thanks to the individual measurement, adjustments can be made for each Aeroleaf® generator type.

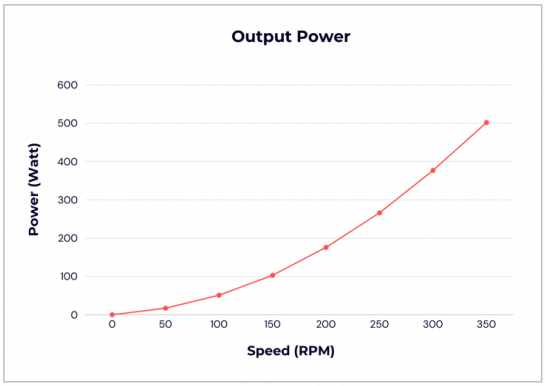
Each Aeroleaf® MWT is individually readable via a proprietary developed PCB card via a Modbus type RTU RS485 in which the following KPIs are measured: ignition time, control mode, average input voltage, average input current, average output voltage, average output current, input power, output power, efficiency, rotation speed. These KPIs are visualized via a PC type Windows10.

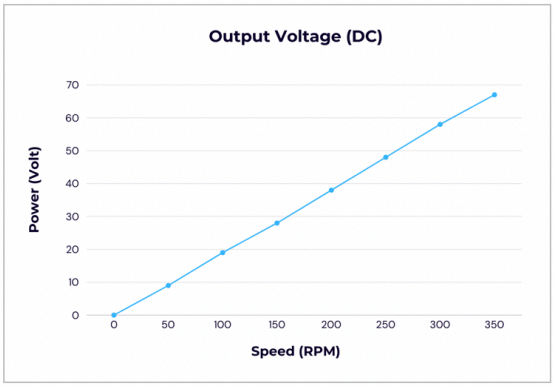
The Model X is executed in all colors where the efficiency of the Aeroleaf® blades is custom maximized adjusted according to the wind report of the local site.

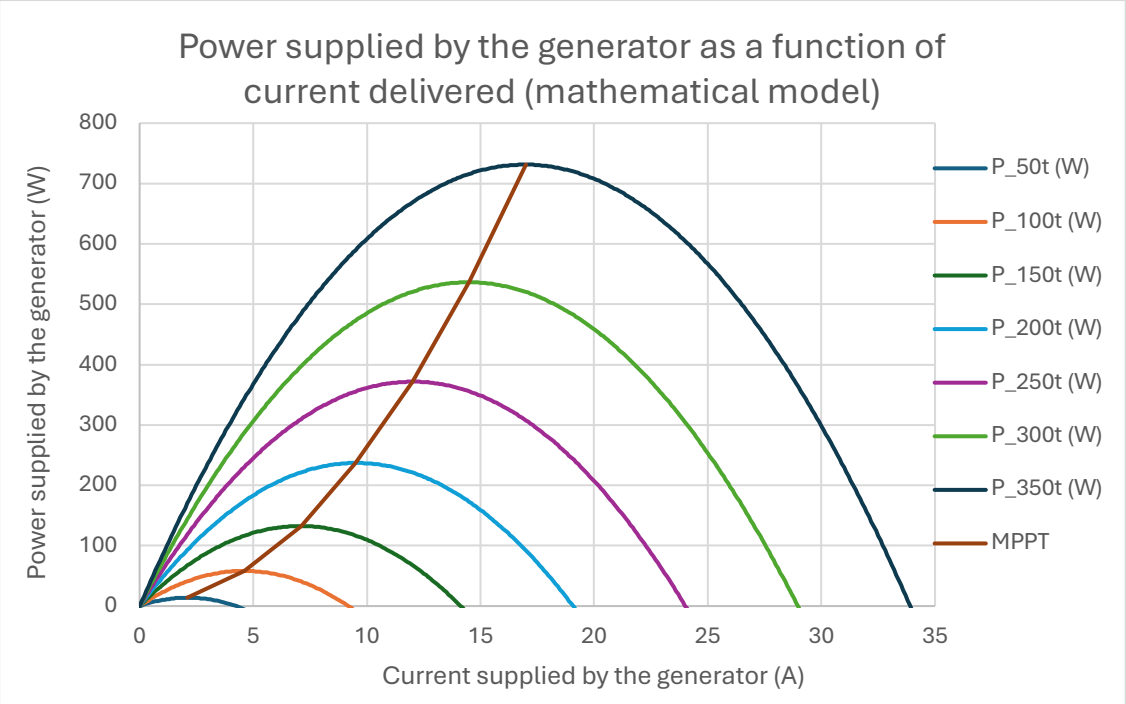
Technical characteristics MWT 500W-350RPM



Rated power	0.5 kW
Rated speed	350 rpm
Rated voltage	28 Volt DC / 56 Volt DC
Rated line current	6,44 A / 12,88 A
Efficiency	> 85%
Resistance (line-line)	-
Winding type	Y-configuration
Insulation resistance	Min. 100 Mohm (500 Volt DC)
Leakage level	< 5 mA
Start torque	< 0.1 Nm
Phase	3-phase
Structure	Outer rotor
Stator	Coreless
Rotor	Permanent magnet type
Diameter	265 mm
Length	199,5 mm
Weight	11 kg
Shaft diameter	30 mm
Housing material	Aluminium alloy
Shaft material	Steel
Gross Weight	15 kg



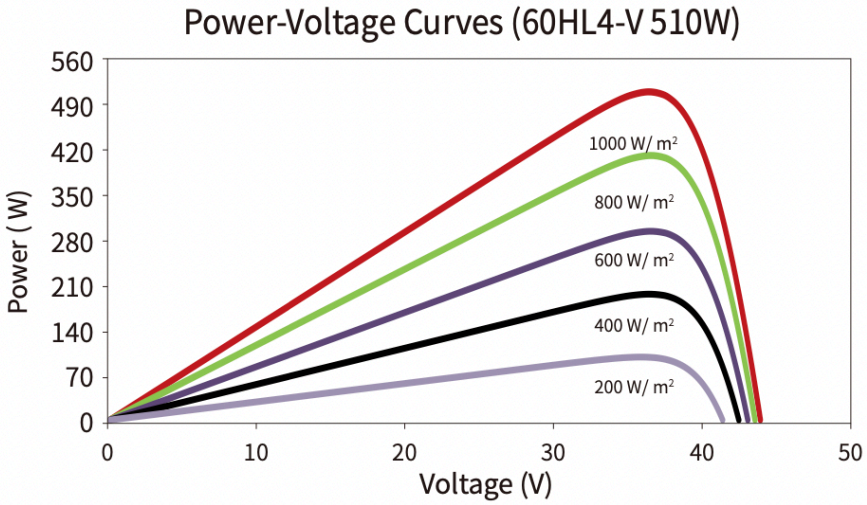




Solar Panels

3 x Solar panel Jinko JKM-435N-54HL4R-BDV Bifacial transparent back sheet (565 Wp), horizontally mounted & 3 x solar panel transparent 300Wp (vertical). During further progression, the transparent vertical solar panels and the Aeroleaf® MKT MK1 (ABS version) were not retained.

Electrical Performance



Inverter

Victron Energy, a Dutch global player, specialises in energy and its products are of high quality. Victron is the world market leader in power supply products: battery chargers, inverters, DC-DC converters and also related accessories such as cables, battery monitors, solar regulators,...

In this project, we enjoyed the full cooperation of Victron Belgium

Victron Energy's MultiPlus-II inverter is a special version of the charger/inverter MultiPlus and especially developed for grid-connected battery storage systems. To comply with the VDE-AR-N 4105 standard, several hardware and firmware modifications have been made.

This makes installation easier (fewer components) and therefore cheaper.

The MultiPlus-II is available for 48V, for capacities from 3000VA to 15000VA.

The MultiPlus-II is a multifunctional inverter/charger with all the functions of the MultiPlus, plus an external current sensor option that extends the PowerControl and PowerAssist functions to 50A or 100A.

The MultiPlus-II is ideally suited for professional marine, yachting, vehicle and land-based applications without mains connection. It also has a built-in anti-islanding function and a growing list of country approvals for ESS applications. Various system configurations are possible. For more detailed information, see the ESS design and configuration manual. PowerControl en PowerAssist - Het verhogen van de capaciteit van het stroomnet of een stroomgenerator

A maximum grid or generator current can be set. The MultiPlus-II will then take other AC loads into account and use any extra current to charge the battery, preventing the generator or grid from being overloaded (PowerControl function).

PowerAssist takes the principle of PowerControl to the next level. Where peak power is often only required for a limited period, the MultiPlus-II compensates for insufficient generator, shore or grid power with power from the battery. When the load decreases, the reserve power is used to recharge the battery.

The MultiPlus-II can be used in both grid-independent PV/wind and grid-connected PV and other alternative energy systems. It is compatible with both solar charger controllers and grid development inverters.

Two AC outputs

The main output has no pause functionality. The MultiPlus-II takes over the supply to the connected loads, in case of a power failure or when the shore power/generator voltage is disconnected. This happens so quickly (in less than 20 milliseconds) that computers and other electronic equipment can continue to operate without interruption.

The second output is active only when AC power is available at the input of the MultiPlus-II. Loads that should not discharge the battery, such as a boiler for example, can be connected to this output. Vrijwel onbeperkt vermogen dankzij parallel en 3-fasen werking

Up to six Multi's can operate in parallel to achieve higher output power. For example, six 48/5000/70 units can provide an output power of 25 kW / 30 kVA with a load capacity of 420 amps.

In addition to parallel connection, three units of the same model can be configured for three-phase output. But that's not all: up to 6 sets of three units can be connected in parallel for a 75 kW / 90 kVA inverter and more than 1200 amps of load capacity.

On-site configuration, monitoring and control.

Settings can be changed within minutes with the VEConfigure software (computer or laptop and an MK3-USB interface required).

Several monitoring and control options are available: Color Control GX, Venus GX, Octo GX, CANvu GX, laptop, computer, Bluetooth (with the optional VE.Bus Smart dongle), Battery Monitor, Digital Multi Control Panel.

VRM-portaal
Onze gratis bewakingswebsite (VRM) toont alle systeemgegevens in een uitgebreid grafisch formaat. Systeeminstellingen kunnen gewijzigd worden via het portaal. Alarmmeldingen kunnen per e-mail of pushbericht ontvangen worden.

Cerbo GX: communication centre

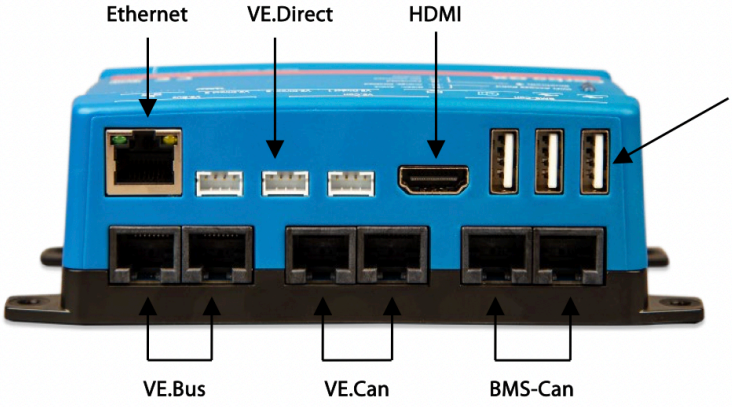
With this communication centre, you always have perfect control of your system, wherever you are, and can maximise performance. Easily connect via the Victron Remote Management (VRM) portal, or access it directly via the separate GX Touch 50, a multifunction display (MFD) or via VictronConnect app thanks to the added Bluetooth functionality. This latest addition to the GX series combines the best of connectivity and redefines smart energy solutions in every way.

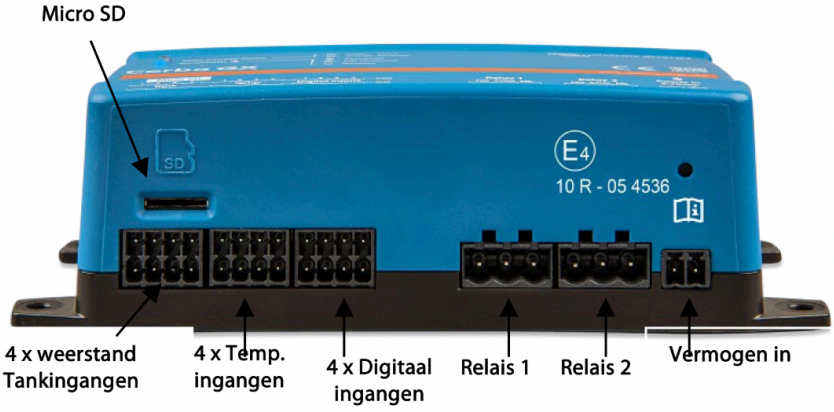
Remote Console on VRM

Monitor, control and adjust the Cerbo GX remotely, over the internet. As if you were in front of the device, via remote console. The same functionality is also available on the local LAN network, or via the Cerbo GX's WiFi access point.

Perfect monitoring & control

Monitor current battery charge status, power consumption, energy output, genset and mains voltage, or check tank levels and temperature readings. Easily set shore power input current limit, (auto)start/stop genset(s) or change a setting to optimise the system. Investigate alerts, perform diagnostic checks and resolve problermen remotely.





Energy storage systems

Pylontech's lithium battery is specifically designed for energy storage in residential and SME environments. Its modular design allows up to 16 modules with a rated capacity of 4.8kWh to be connected in parallel. From 17 modules upwards, an LV-Hub must be used. The 19' modules can be rack-mounted or stacked up to 4 modules using optional brackets.

Each module, rated at 48VDC, has a built-in BMS (Battery Management System) to protect the cells from extreme temperatures, voltages, currents, SoC and SoH. The battery is designed for a life of 6000 cycles at a DoD of 90% at 25°C.

The modules come standard with cables to connect multiple modules in parallel. The connection cable to the inverter should be ordered separately as well as the data cable (CAN).

The Pylontech Lithium batteries can be perfectly integrated in a Victron Energy ESS system.

Support structures

All support structures in steel are provided with KTL treatment and powder coating as standard. If required, the structures can only be galvanised. Both versions guarantee total protection in all weather conditions. We are happy to work with you on your customised designs. A deviation from the standard RAL colours was made in Ardooie to form a unity with the existing green colour of the high-voltage cabin.

Standard RAL colours:

- RAL 7016 (anthracite grey)
- RAL 7021 (black grey)
- RAL 9005 (finely structured jet black matt)
- RAL 9010 (off-white)

Installation Aeroleaf®

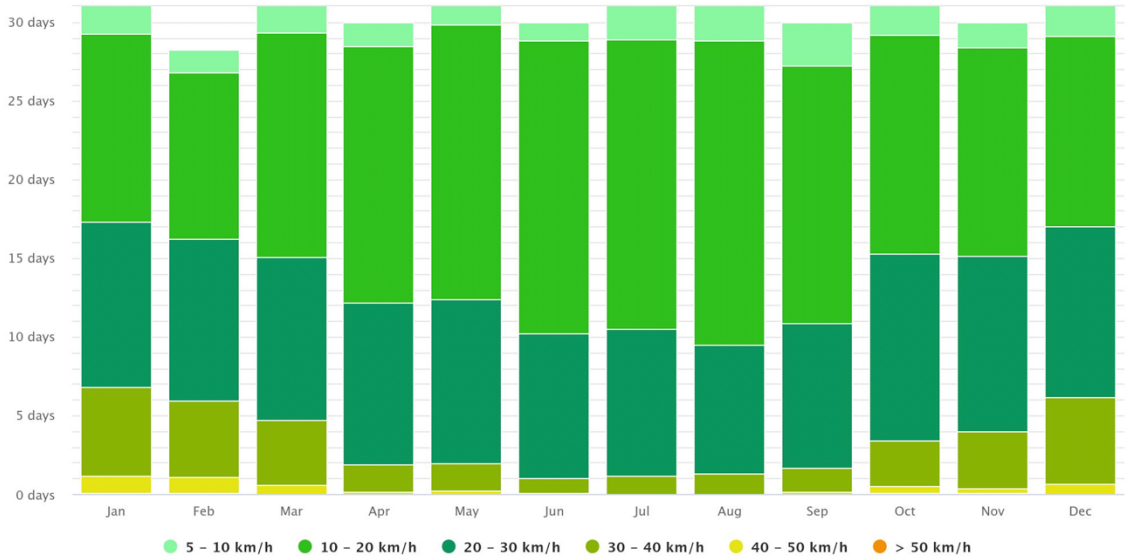
For the installation of our Aeroleaf® ® wind turbines, we work closely with the highly qualified professionals of Bluebridge Electrical Services. They have the most modern techniques at their fingertips and their work excels through precision down to the smallest detail. They can also take care of the certificates, attestations and inspections.

RESULTS

Wind speeds: historical, weather station and MWT

Several measurements were done based on the different channels: historical, weather station and through the circuit boards of the Microwind Turbines (MWT). We started by studying what the historical data is on site.

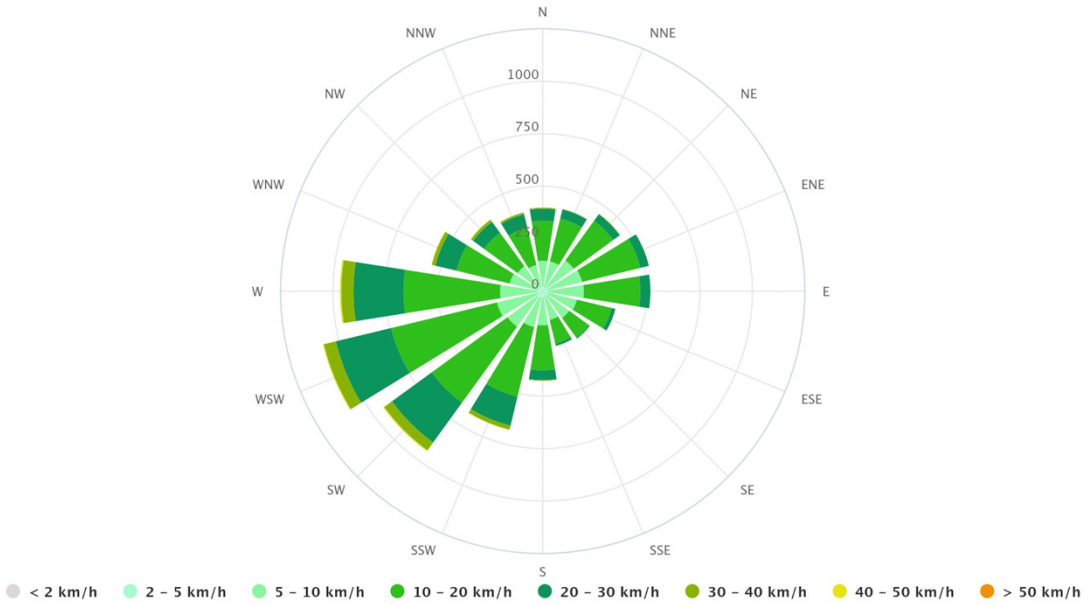
Ardooie
50.98°N, 3.20°E (21 m asl).
Model: ERA5T.



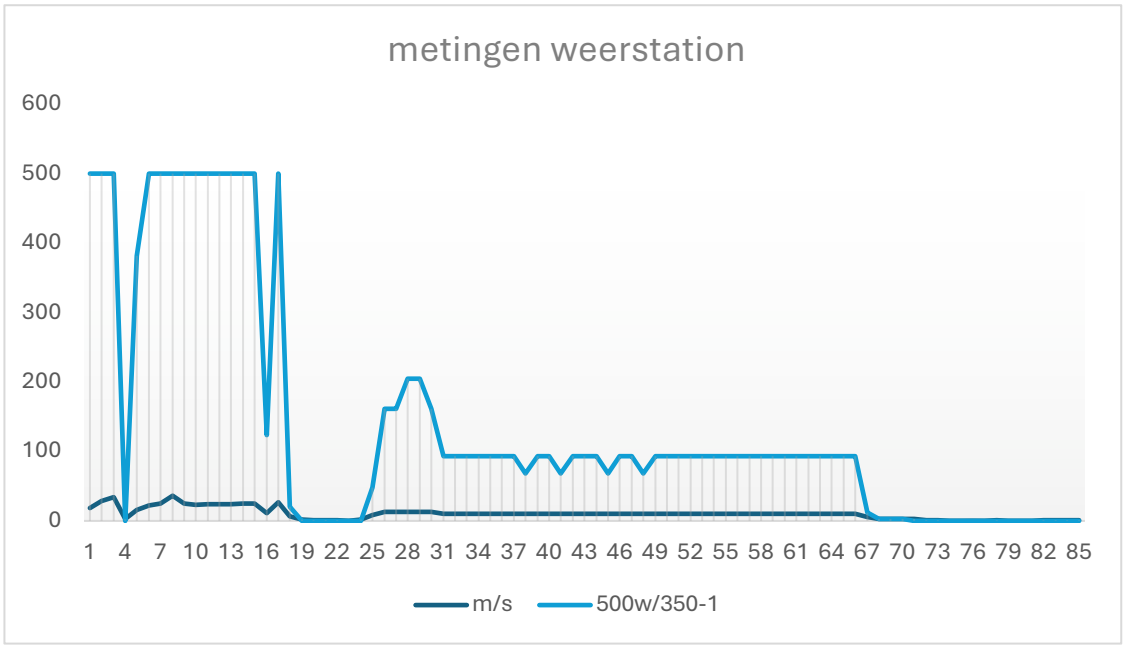
We learn from this data that there is enough wind present to calculate the minimum starting speed of the turbines (2m/s or 7.2 km/h = light green), every month there are values to note of more than 50% wind speeds with values between 10 and 30 km/h or 2.7 m/s and 8.3 m/s. There are peaks up to 50 km/h or 13.8m/s.

The wind direction is mainly from the south-southwest.

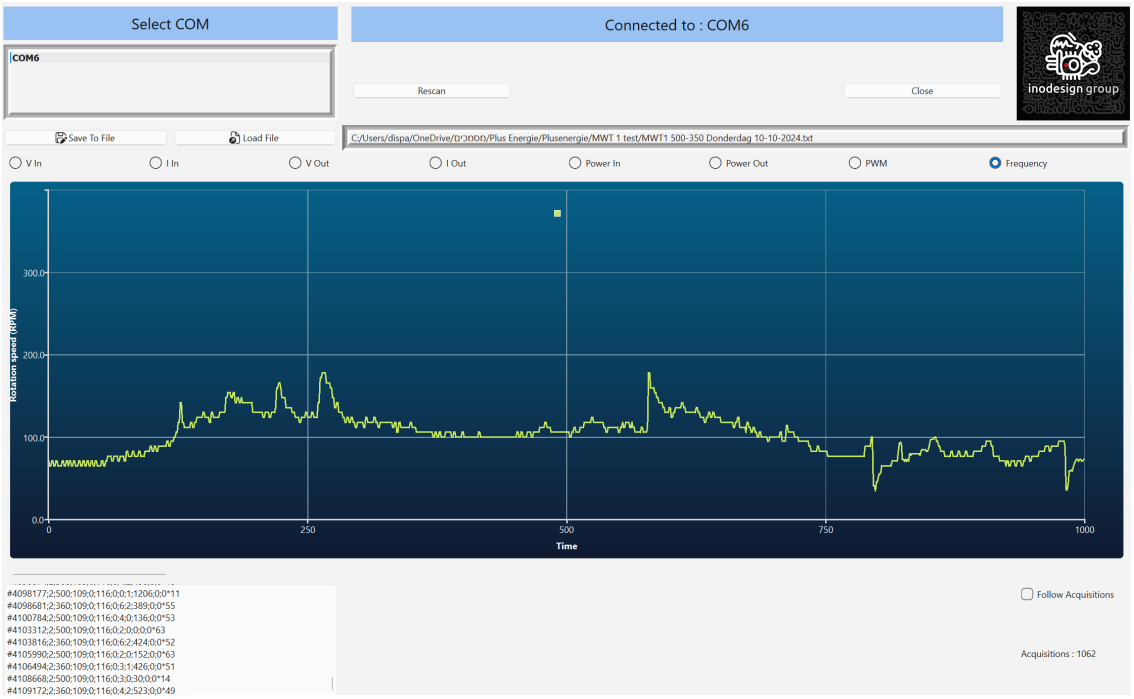
Ardooie
50.98°N, 3.20°E (21 m asl).
Model: ERA5T.

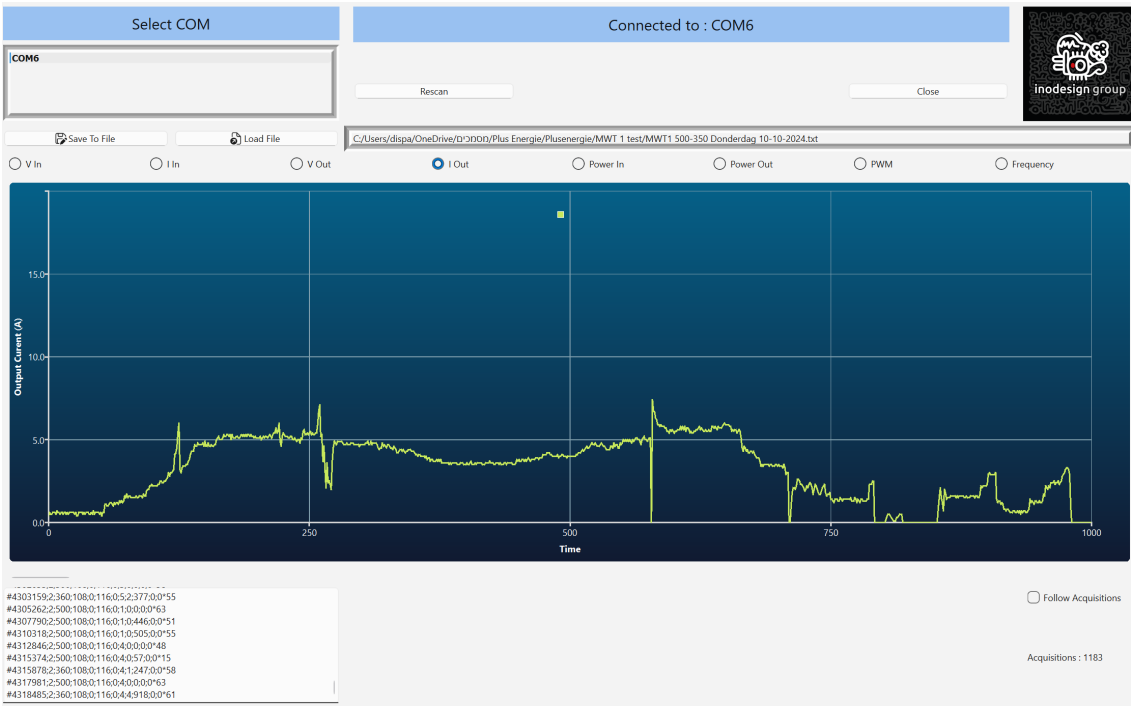


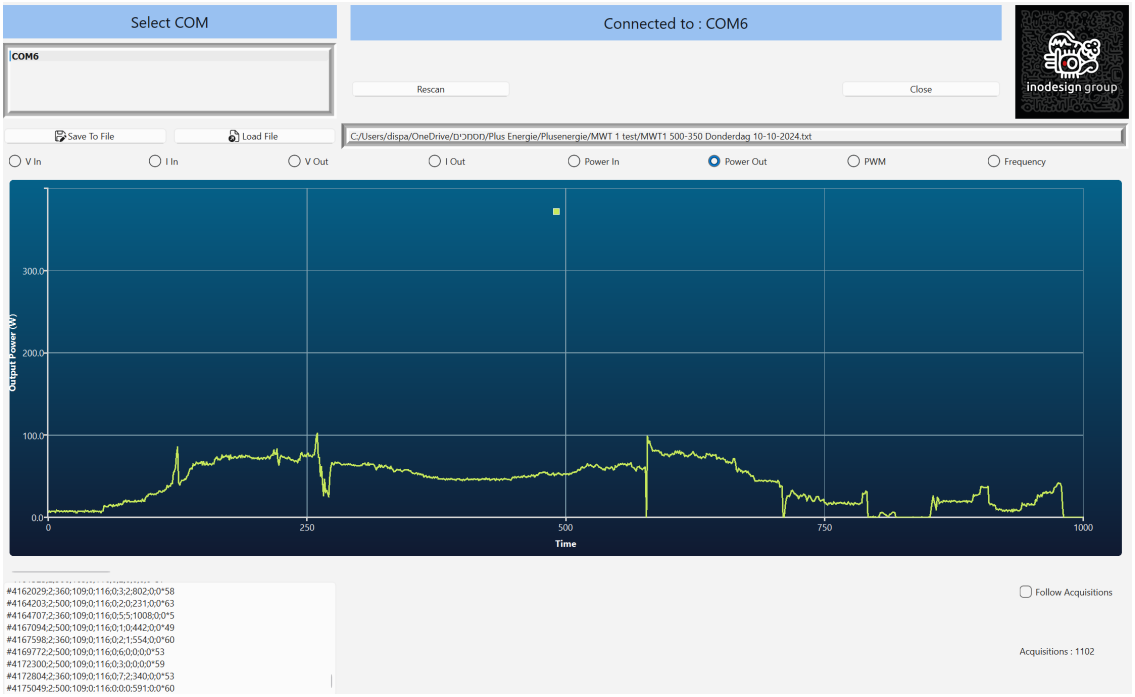
Weather station measurements confirmed the historical values. Peaks of over 50 km/h or 13.88 m/s were registered where peak values (500W) were achieved.

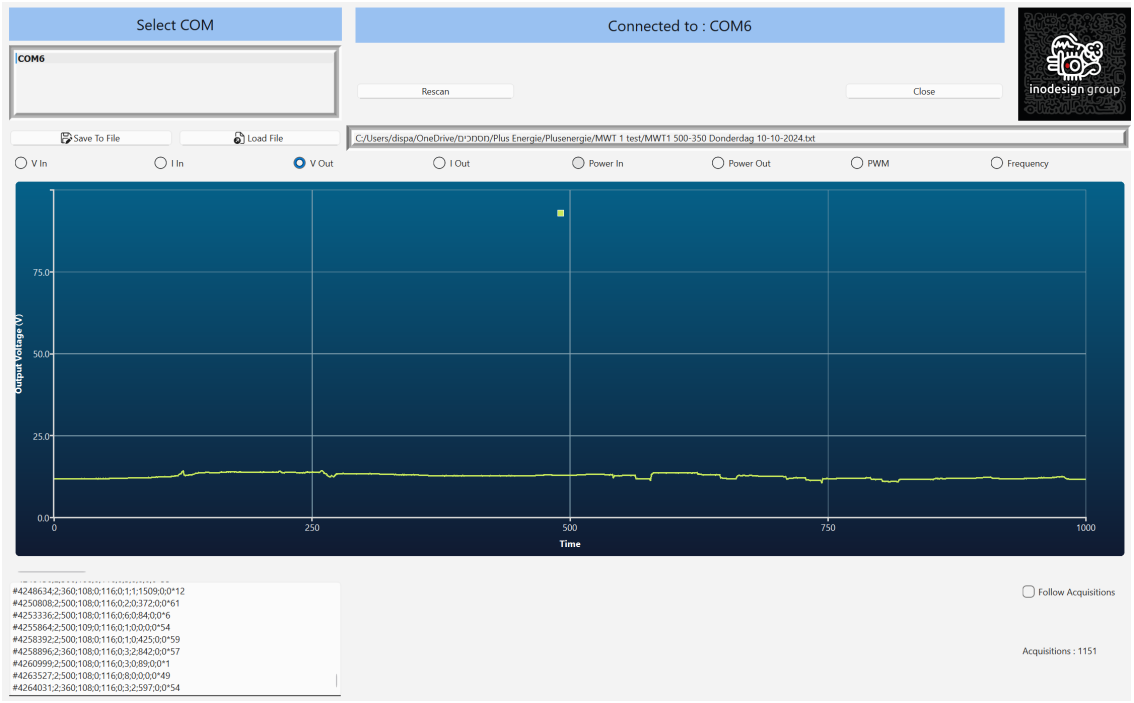


We then extracted the measurements during a specific period from the Aeroleaf® MWTs. A Modbus was installed on the boards where we log data such as the RPM and output in KW which can be visualized via a screen and an export.

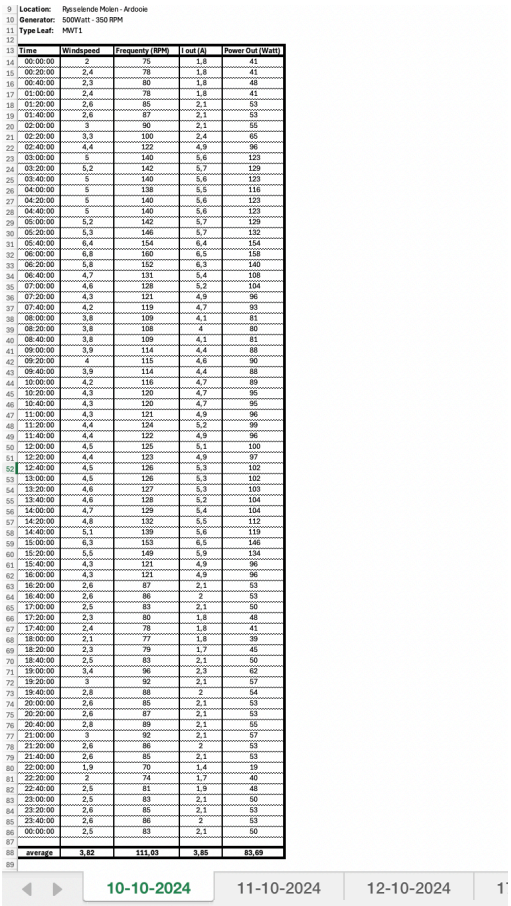



Select COM
Connected to : COM6
COM6
Rescan
Close
inodesign group
Save To File
Load File
C:/Users/dispa/OneDrive/Documenten/Plus Energie/Plusenergie/MWT 1 test/MWT1 500-350 Donderdag 10-10-2024.txt
V In
I In
V Out
I Out
Power In
Power Out
PWM
Frequency
Output Current (A)
15.0
10.0
5.0
0.0
0
250
500
750
1000
Time
#4303159;2;360;108;0;116;0;5;2;377;0;0*55
#4305262;2;500;108;0;116;0;1;0;0;0;0*63
#4307790;2;500;108;0;116;0;1;0;446;0;0*51
#4310318;2;500;108;0;116;0;1;0;505;0;0*55
#4312846;2;500;108;0;116;0;4;0;0;0;0*48
#4315374;2;500;108;0;116;0;4;0;57;0;0*15
#4315878;2;360;108;0;116;0;4;1;247;0;0*58
#4317981;2;500;108;0;116;0;4;0;0;0;0*63
#4318485;2;360;108;0;116;0;4;4;918;0;0*61
Follow Acquisitions
Acquisitions : 1183


Select COM
Connected to : COM6
COM6
Rescan
Close
inodesign group
Save To File
Load File
C:/Users/dispa/OneDrive/Documenten/Plus Energie/Plusenergie/MWT 1 test/MWT1 500-350 Donderdag 10-10-2024.txt
V In
I In
V Out
I Out
Power In
Power Out
PWM
Frequency
Output Power (W)
300.0
200.0
100.0
0.0
0
250
500
750
1000
Time
#4162029;2;360;109;0;116;0;3;2;802;0;0*58
#4164203;2;500;109;0;116;0;2;0;231;0;0*63
#4164707;2;360;109;0;116;0;5;5;1008;0;0*5
#4167094;2;500;109;0;116;0;1;0;442;0;0*49
#4167598;2;360;109;0;116;0;2;1;554;0;0*60
#4169772;2;500;109;0;116;0;6;0;0;0;0*53
#4172300;2;500;109;0;116;0;3;0;0;0;0*59
#4172804;2;360;109;0;116;0;7;2;340;0;0*53
#4175049;2;500;109;0;116;0;0;0;591;0;0*60
Follow Acquisitions
Acquisitions : 1102

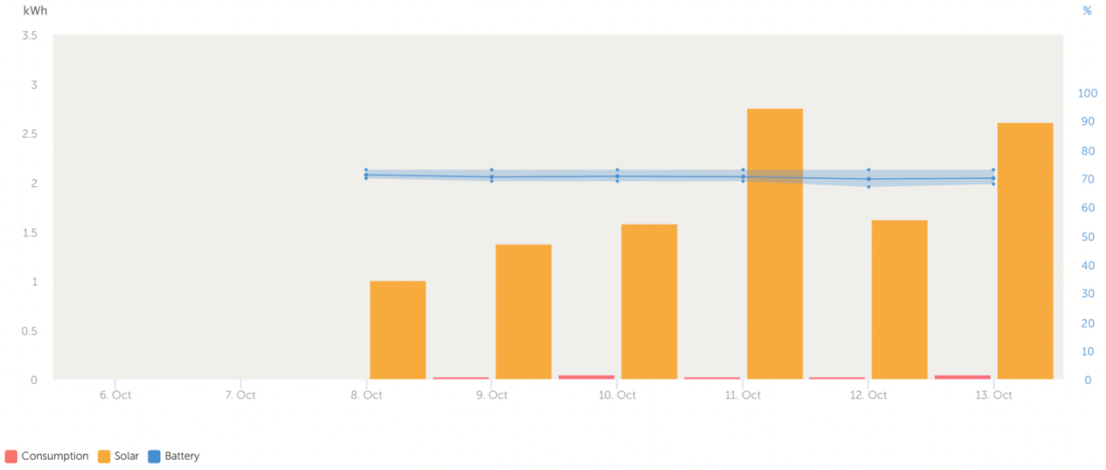


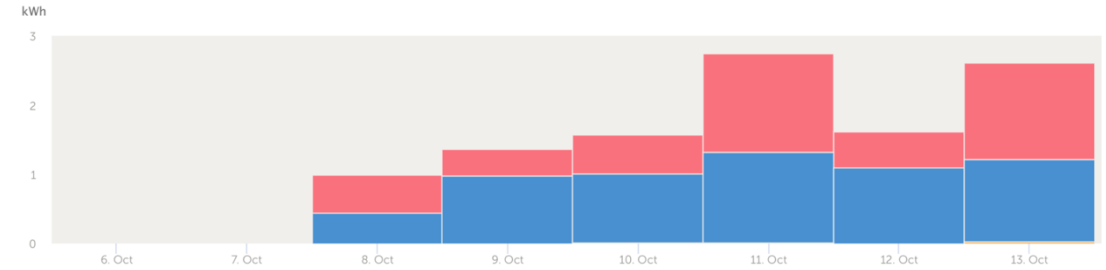
The measured data from 1 x Aeroleaf® MWT. We note that there was not much wind but this is still enough, together with the solar panels, to keep the battery at 70% (=3.22Kwh) and there are surpluses. The preliminary set parameters of the battery are 70 -> 73%.



Location: Rysselende Molen - Ardooie
Generator: 500Watt - 350 RPM
Type Leaf: MWT1

Time	Windspeed	Frequenty (RPM)	I out (A)	Power Out (Watt)
00:00:00	2	75	1,8	41
00:20:00	2,4	78	1,8	41
00:40:00	2,3	80	1,8	48
01:00:00	2,4	78	1,8	41
01:20:00	2,6	85	2,1	53
01:40:00	2,6	87	2,1	53
02:00:00	3	90	2,1	55
02:20:00	3,3	100	2,4	65
02:40:00	4,4	122	4,9	96
03:00:00	5	140	5,6	123
03:20:00	5,2	142	5,7	129
03:40:00	5	140	5,6	123
04:00:00	5	138	5,5	116
04:20:00	5	140	5,6	123
04:40:00	5	140	5,6	123
05:00:00	5,2	142	5,7	129
05:20:00	5,3	146	5,7	132
05:40:00	6,4	154	6,4	154
06:00:00	6,8	160	6,5	158
06:20:00	5,8	152	6,3	140
06:40:00	4,7	131	5,4	108
07:00:00	4,6	128	5,2	104
07:20:00	4,3	121	4,9	96
07:40:00	4,2	119	4,7	93
08:00:00	3,8	109	4,1	81
08:20:00	3,8	108	4	80
08:40:00	3,8	109	4,1	81
09:00:00	3,9	114	4,4	88
09:20:00	4	115	4,6	90
09:40:00	3,9	114	4,4	88
10:00:00	4,2	116	4,7	89
10:20:00	4,3	120	4,7	95
10:40:00	4,3	120	4,7	96
11:00:00	4,3	121	4,9	96
11:20:00	4,4	124	5,2	99
11:40:00	4,4	122	4,9	96
12:00:00	4,5	125	5,1	100
12:20:00	4,4	123	4,9	97
12:40:00	4,5	126	5,3	102
13:00:00	4,5	126	5,3	102
13:20:00	4,6	127	5,3	103
13:40:00	4,6	128	5,2	104
14:00:00	4,7	129	5,4	104
14:20:00	4,8	132	5,5	112
14:40:00	5,1	139	5,6	119
15:00:00	6,3	153	6,5	146
15:20:00	5,5	149	5,9	134
15:40:00	4,3	121	4,9	96
16:00:00	4,3	121	4,9	96
16:20:00	2,6	87	2,1	53
16:40:00	2,6	86	2	53
17:00:00	2,5	83	2,1	50
17:20:00	2,3	80	1,8	48
17:40:00	2,4	78	1,8	41
18:00:00	2,1	77	1,8	39
18:20:00	2,3	79	1,7	45
18:40:00	2,5	83	2,1	50
19:00:00	3,4	96	2,3	62
19:20:00	3	92	2,1	57
19:40:00	2,8	88	2	54
20:00:00	2,6	85	2,1	53
20:20:00	2,6	87	2,1	53
20:40:00	2,8	89	2,1	55
21:00:00	3	92	2,1	57
21:20:00	2,6	86	2	53
21:40:00	2,6	85	2,1	53
22:00:00	1,9	70	1,4	19
22:20:00	2	74	1,7	40
22:40:00	2,5	81	1,9	48
23:00:00	2,5	83	2,1	50
23:20:00	2,6	85	2,1	53
23:40:00	2,6	86	2	53
00:00:00	2,5	83	2,1	50
average	3,82	111,03	3,85	83,69





ROI en BUDGET

Budget

Quatity	what	Budget exclusive VAT
10	Aeroleaf® MWT 500Wp-350 RPM (5KWp)	€ 6.800,00
6	PV 580Wp (3,48KWp)	€ 1.000,00
1	battery P5000us (4,6KWh)	€ 1.500,00
1	Victron inverter 3KW	€ 1.000,00
1	Support structure	€ 1.000,00
1	work installation	€ 1.000,00
1	material en cables	€ 500,00
	Total (8,48 KWp + 4,6 KWh)	**€ 12.800,00**

This budget is gebased on minimum installation 25 locations

ROI

Minimu

Slumber consumption ROI calculation:

3kwh x 24h x 365d x 4years (= starting point maximum payback time ROI) x purchase price of electricity* = budget installation

Without additional costs: minimum €0.08 = €8,500.00
Flanders digital meter incl. additional costs: min. €0.24 = €25,228.80
Brussels & Wallonia incl. additional costs: min. €0.30 = €31,536.00

* Depending on the type of energy meter, the chosen energy supplier and the tariff, the price of electricity will be between €0.08 and €0.20 per kWh in 2024. The final price you pay (including all additional costs) for electricity will be around €0.40 in October 2024.

Price differences for electricity per region

	min	max
VLAANDEREN	**€ 0,24**	**€ 0,36**
VLAANDEREN digitale meter	**€ 0,21**	**€ 0,33**
BRUSSEL	**€ 0,30**	**€ 0,36**
WALLONIË	**€ 0,30**	**€ 0,43**

(on 18th sep 2024)

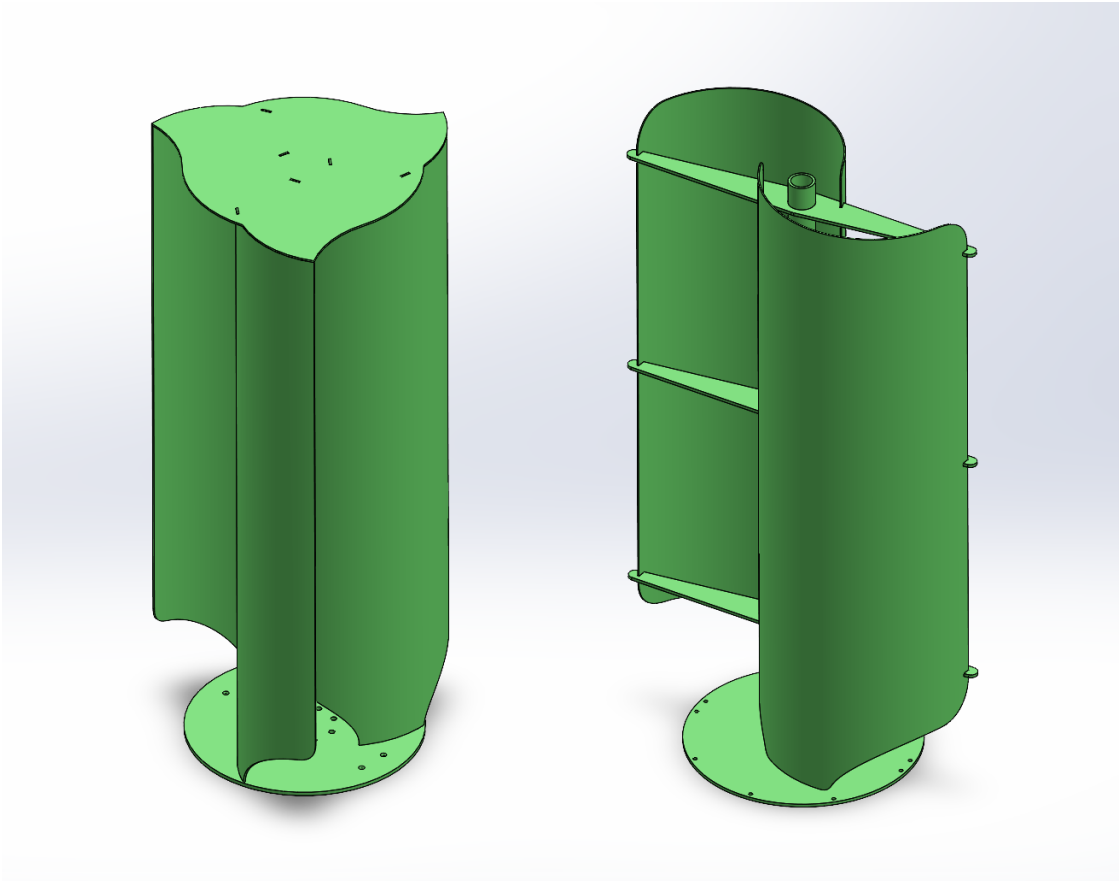
Payback time ROI based on €0.20 = €5,256.00
Budget €12,800.00 : €5,256.00 = 2.43 years

ONGOING DEVELOPMENTS 2025

Always there is a progressive insight whereby customer comments, collaborations with universities and study agencies, creating a platform to invest again and again to harvest the best possible wind. This results in new initiatives where we challenge various parties to ensure that the MWT is a fully affordable product.

MWT X2

The desired wind energy is determined by various parameters such as, of course, the wind speed, the surface area of the wind blades, the type of generator, the wind capture according to Betz law, ... By means of our own calculation module, we can work to size for these models. To do this, we use recyclable aluminum, whether powder-coated or not, which is laser-cut to size so that we can deviate from the specified dimensions. At the Ardooie site, we have already tested the MWT X model and have found that the larger surface area contributes to efficiency. We are now working on a model MWT X2 in which we increase the Savonius coefficient through additional pawls.



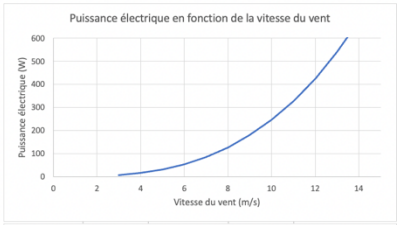
CONSTANTES			
Description	Symbole	Unité	Valeur
Masse volumique de l'air à 20°C	ρ	kg/m3	1,204

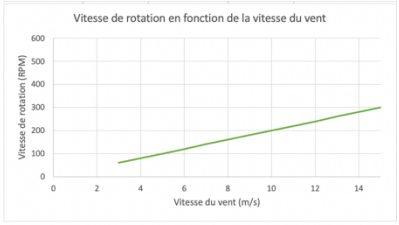
PARAMETRE			
Description	Symbole	Unité	Plage
Puissance électrique nominale	Pe	W	500
Vitesse de rotation nominale	Ω	RPM	350
Vitesse du vent nominal	v	m/s	17,5
Coefficient de puissance Savonius	Cp	.	0,4
Rapport de vitesse Savonius	λ	.	1

CALCULS				
Description	Symbole	Unité	Formule	Calculs
Puissance mécanique	Pm	W	Pe/0,85	588,235
Puissance cinétique	Pc	W	Pm/Cp	1470,588
Surface de la pale	S	m^2	Pc*2/(ρ.v^3)	0,456
Vitesse rotation	ω	rad/s	2πΩ/60	36,651
Rayon de la pale	R	m	λ.v/ω	0,477
Hauteur de la pale	H	m	S/2R	0,477

RESULTATS			
Hauteur de la pale	H	m	0,477
Rayon de la pale	R	m	0,477
Surface de la pale	S	m^2	1,200

v	Pc	Pm	Pe	ω	Ω
3	20	8	7	6,28	60
4	46	18	16	8,38	80
5	90	36	31	10,47	100
6	156	62	53	12,57	120
7	248	99	84	14,66	140
8	370	148	126	16,75	160
9	527	211	179	18,85	180
10	722	289	246	20,94	200
11	962	385	327	23,04	220
12	1248	499	424	25,13	240
13	1587	635	540	27,23	260
14	1982	793	674	29,32	280
15	2438	975	829	31,42	300
16	2959	1184	1006	33,51	320
17	3549	1420	1207	35,60	340
18	4213	1685	1432	37,70	360
19	4955	1982	1685	39,79	380
20	5779	2312	1965	41,89	400
21	6690	2676	2275	43,98	420
22	7692	3077	2615	46,08	440
23	8789	3516	2988	48,17	460
24	9986	3995	3395	50,26	480
25	11288	4515	3838	52,36	500
26	12697	5079	4317	54,45	520
27	14219	5688	4834	56,55	540
28	15858	6343	5392	58,64	560
29	17619	7047	5990	60,74	580
30	19505	7802	6632	62,83	600





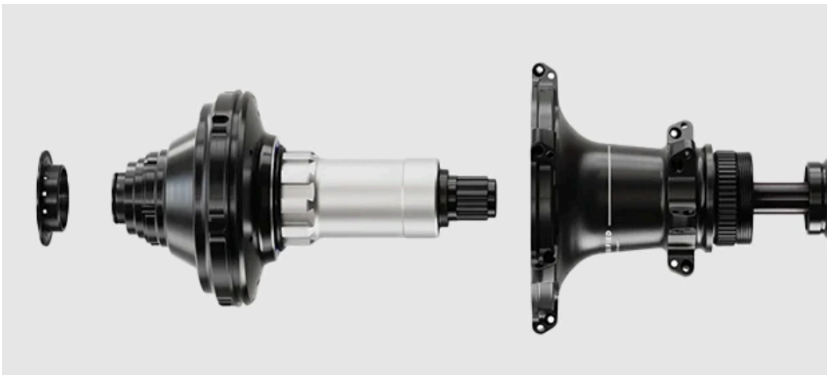
Vitesse du vent moyen (m/s)	Repartition	Puissance (W)	Puissance repartie (W)
0,0	0,1	0,00	0,00
3,0	0,72	6,63	4,77
10,0	0,18	245,62	44,21
15,0	0	828,95	0,00
20,0	0	1964,93	0,00

Online dashboard

Each Aeroleaf® ® MWT has its own PCB card where we can adjust the programming and read out the data. In addition to extracting data per energy group per site via the Cerbo GX, this data will be able to be consolidated online in real time across the different sites per Aeroleaf® MWT.

E gear

Wind is always there in gusts and can sometimes drop dead. To still ensure that at lower wind speeds, the turbine spins faster, we are investigating with various agencies the vertical integration of an E gear via our own circuit board, where we measure the RPM, to be electronically controlled. The objective is there to such that we never fall below the RPM minimum.



Remarks: