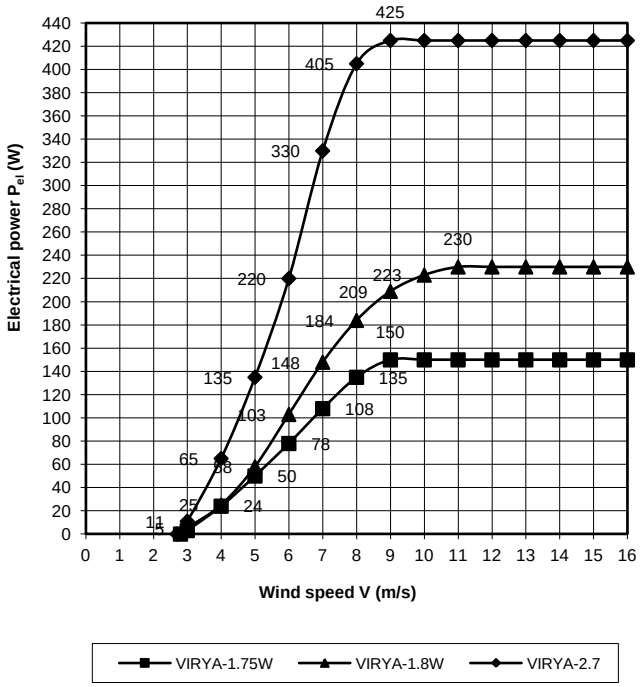
Free licence for manufacture and sale of windmills

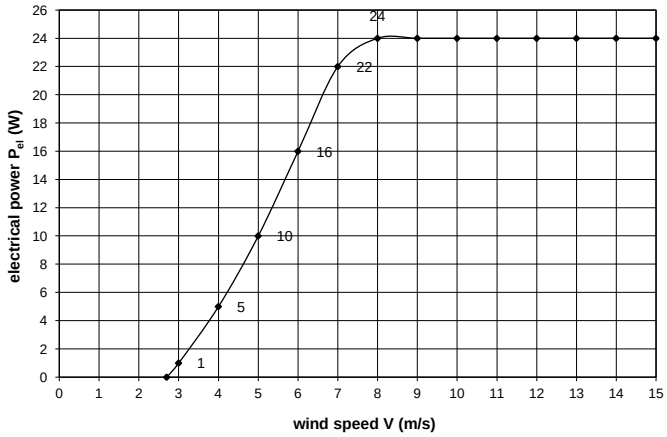
VIRYA-1.02, VIRYA-1.75W, VIRYA-1.8W, VIRYA-2.7 and VIRYA-1.38

September 2023

P_{el}-V curves VIRYA-1.75W, VIRYA-1.8W and VIRYA-2.7 windmills



P_{el}-V curve VIRYA-1.02 windmill



Specification

	VIRYA-1.02	VIRYA-1.75W	VIRYA-1.8W	VIRYA-2.7
Rotor diameter	D = 1.02 m	D = 1.75 m	D = 1.8 m	D = 2.7 m
Number of blades	B = 3	B = 2	B = 2	B = 3
Design tip speed ratio	λ_d = 3.5	λ_d = 7	λ_d = 6.25	λ_d = 6
Blade material	stainless steel	wood	wood	wood
Gear ratio	i = 1	i = 1	i = 1	i = 1
Rotor eccentricity	e = 0.09 m	e = 0.15 m	e = 0.15 m	e = 0.23 m
Generator type	axial flux	axial flux	radial flux	axial flux
Number of poles and phases	8-pole, 3-phase	?-pole, 3-phase	8-pole, 3-phase	?-pole, 3-phase
Height tower pipe	H = 1 m	H = 2 m	H = 2 m	H = 2 m
Total tower height	H_{tot} = 3.7 m	H_{tot} = 7.8 m	H_{tot} = 7.8 m	H_{tot} = 7.5 m
Mass with tower pipe only	m = 5.6 kg	m = 19 kg	m = 22 kg	m = 41 kg
Starting wind speed	V_{start} = 1.5 m/s	V_{start} = 3.2 m/s	V_{start} = 2.3 m/s	V_{start} = 1.9 m/s
Cut in wind speed (if started)	$V_{cut\ in}$ = 2.7 m/s	$V_{cut\ in}$ = 2.8 m/s	$V_{cut\ in}$ = 2.6 m/s	$V_{cut\ in}$ = 2.7 m/s
Rated wind speed	V_{rated} = 8 m/s	V_{rated} = 9 m/s	V_{rated} = 11 m/s	V_{rated} = 9 m/s
Survival wind speed	V_{surv} = 30 m/s	V_{surv} = 35 m/s	V_{surv} = 35 m/s	V_{surv} = 35 m/s
Nominal battery voltage	U = 12 V DC	U = 12 V DC	U = 24 V DC	U = 24 V DC
Power at rated wind speed	P_{rated} = 24 W	P_{rated} = 150 W	P_{rated} = 230 W	P_{rated} = 425 W
Rotor calculations	report KD 678	report KD 669	report KD 664	report KD 717
Generator description	report KD 679	report KD 595	report KD 644	report KD 717
Licence fee	free	free	free	free

Kragten Design

Kragten Design (KD) is a one man engineering office founded in 1989 and specialises in windmill design. Up to now 26 windmills with rotor diameters from 0.98 up to 4.6 metre haven been developed and 747 KD-reports haven been written. Adriaan Kragten, B.Sc., worked for fifteen years in the Wind Energy Group, Faculty of Physics of the University of Technology Eindhoven, one of the parties of the former CWD (Consultancy services Wind energy Developing countries). Kragten Design is no longer a commercial company from 1 January 2018.

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Description of the windmills

The 3-bladed VIRYA-1.02 is an alternative for the 2-bladed VIRYA-1. The VIRYA-1.02 has rectangular stainless steel blades which aren't cambered but for which the sides are 15° bent forwards. Therefore no complex tools are needed to camber and twist the blades. The head and tower of the VIRYA-1.02 are the same as those used for the VIRYA-1.04. The VIRYA-1.02 makes use of a generator which is made from the front wheel hub of a mountain bike. The generator is the same as the VIRYA-1 generator and it is described in report KD 679. The rotor calculations and the rotor drawings are given in public report KD 678.

The rotor blades of the 2-bladed VIRYA-1.75W and VIRYA-1.8W and the 3-bladed VIRYA-2.7 windmills are made out of wood. A W is added behind the name of the first two windmills to distinguish them from the VIRYA-1.75 and the VIRYA-1.8 with cambered stainless steel blades. The VIRYA-1.75W has constant chord blades with a Gö 611-10% airfoil made out of hard wood. The VIRYA-1.8W has constant chord blades with a Gö 711-12% airfoil made out of water proof plywood. The VIRYA-2.7 has constant chord blades with a Gö 623 or a Gö 711-12% airfoil made out of hard wood. The airfoil is made over the whole blade length. The blades of 2-bladed rotors are connected to each other by a twisted stainless steel strip which makes the rotors rather elastic. The three blades of the VIRYA-2.7 are connected to a hub plate made out of galvanised steel sheet.

The rotor calculations and the rotor drawings for the VIRYA-1.75W are given in public report KD 669. The rotor calculations and the rotor drawings for the VIRYA-1.8W are given in public report KD 664. The rotor calculations for the VIRYA-2.7 are given in public report KD 717. Detailed drawings of the VIRYA-2.7 rotor were not yet made but figure 1 of KD 717 gives a sketch of the rotor. If someone wants to build a prototype of the VIRYA-2.3, I can make detailed drawings of the rotor if wanted.

The VIRYA-1.75W makes use of an axial flux PM-generator of the Chinese company Hefei Top Grand model TGET165-0.15KW-500R. This generator was bought and measured in 2015 and the measurements are given in public report KD 595. This generator was tested for a year in combination with the 2-bladed VIRYA-1.65 rotor with cambered stainless steel blades but this rotor appeared to be too noisy. It was also tested for some years with the 3-bladed VIRYA-1.46 rotor with cambered stainless steel blades but it was still rather noisy. It is expected that the VIRYA-1.75W rotor with wooden blades is more silent but this has not yet been verified. The VIRYA-1.8W makes use of a radial flux PM-generator with no iron in the coils. This generator is made from a 6-pole asynchronous motor frame size 71. This generator is described in public report KD 644. The VIRYA-2.7 makes use of an axial flux PM-generator of the Chinese company Hefei Top Grand model number TGET260-0.5KW-350R. Characteristics for a 24 V battery load were estimated from available characteristics for a resistor load in chapter 6 of KD 717.

The VIRYA-1.75W and the VIRYA-1.8W make both use of the head and tower of the VIRYA-1.8 windmill. The VIRYA-1.8 tower has a 2 m tubular upper section and a 6 m tubular lower section. Photos of the drawings of the head and tower of this windmill are given in the public manual of the VIRYA-1.81 windmill. The only modification is that for the VIRYA-1.75W, a 2 mm aluminium vane blade has to be used in stead of a 1 mm stainless steel vane blade to get a rated wind speed of 9 m/s and that a special bracket is needed to mount the axial flux generator. A drawing of this bracket is given in KD 669.

The VIRYA-2.7 makes use of the head and tower of the VIRYA-2.68 windmill which has a 2-bladed rotor with cambered stainless steel blades. The same tower has been tested for the VIRYA-2.2S windmill for about ten years. The VIRYA-2.68 has a 2 m long tubular upper section and a 6 m high lattice 4-legs lower section. Drawings of the head and tower are not yet made public but photo's of them can be supplied to the one who is willing to build a prototype of the VIRYA-2.7. A special bracket is needed to mount the axial flux generator to the generator bracket which is used for the original VIRYA-2.68 generator.

The windmills are provided with a "hinged side vane safety system" to limit rotor speed and thrust at high wind speeds. The rotor axis is offset from the tower axis. The vane juts out along the rotor and the vane blade is connected to the vane arm using hinges. At low wind speeds, the vane blade hangs in almost vertical position and the rotor is perpendicular to the wind. At wind speeds higher than about 5 m/s, the rotor starts to turn gradually out of the wind. At very high wind speeds the rotor turns out of the wind by about 70° and the vane blade is almost horizontal. The behaviour of this system is very stable and the rotor speed is well controlled.

The VIRYA-1.02, the VIRYA-1.75W, the VIRYA-1.8W and the VIRYA-2.7 windmills have not yet been built and tested but the safety system has been tested in many bigger windmills. I can test the VIRYA-1.75W rotor on the VIRYA-1.8 head which is placed on top of the 12 m tower of the VIRYA-4.2 if someone else builds the rotor. I will certainly not build and test the radial flux generator of the VIRYA-1.8W. I will certainly not build and test the VIRYA-2.7. So someone else has to build the first prototype and test if the ideas really work. I am interested to hear about the results and will answer questions if it is not quit clear how to build and test a prototype.

These four windmills are designed primarily for serial manufacture in developing countries. However, a prerequisite is that the prescribed material is available. Kragten Design cannot supply materials and parts such as bearings, generators, magnets etcetera. The required workshop skills are sawing, drilling, turning, milling (only the VIRYA-1.8W generator) and welding.

Recently it has been investigated if a Sparta Ion hub motor can be used as generator for a small wind turbine. This research is described in public report KD 745. The peak on the cogging torque appeared to be very high (about 0.7 Nm) so in the first instance it was thought that it is too difficult to design a rotor for this generator which has a starting wind speed which is low enough. However, in chapter 6 of KD 745 it appeared that an acceptable 3-bladed rotor can be designed with a diameter of 1.38 m and a design tip speed ratio $\lambda_d = 2.5$. The starting wind speed is about 3.2 m/s. The stopping wind speed is about 1.5 m/s. The cut-in wind speed is about 2.5 m/s (if the rotor has started). The generator hasn't been measured for a 12 V battery load and the P_{el}-V curve could therefore not be determined but it is expected that the maximum electrical power is about 75 W for a wind speed of 9 m/s and higher.

Licence conditions

No licence is required for manufacture and sale of the VIRYA-1.02, the VIRYA-1.75W, the VIRYA-1.8W, the VIRYA-2.7 and the VIRYA-1.38, so anyone is allowed to build and sell these windmills. It is advised to not deviate from the drawings. Although these windmills have been designed carefully, no responsibility is accepted for the operation of a windmill neither as a whole, nor for any of its separate parts.