

**Extended specification VIRYA windmills for battery charging and water pumping (3.3S). A. Kragten, 25 April 2017**

	<b>VIRYA-1.8D</b>	<b>VIRYA-3.8</b>	<b>VIRYA-4.1</b>
Rotor diameter	D = 1.8 m	D = 3.8 m	D = 4.1 m
Number of blades	B = 3	B = 3	B = 3
Design tip speed ratio	$\lambda_d = 4$	$\lambda_d = 5.25$	$\lambda_d = 5.25$
Material rotor blades	galvanised steel	galvanised steel	galvanised steel
Material head	mild steel	mild steel	mild steel
Material vane blade	galvanised steel	foamed PVC	plywood
Gear ratio	i = 1	i = 1	i = 1
Rotor eccentricity	e = 0.15 m	e = 0.36 m	e = 0.4 m
Height tower pipe	H = 2 m	H = 3 m	H = 3 m
Total tower height	H <sub>tot</sub> = 8 m	H <sub>tot</sub> = 9.5 m	H <sub>tot</sub> = 9.5 m
Number of legs and material lower tower part	one wooden pole	four legs, angle iron	four legs, angle iron
Mass with tower pipe only	m = 26.4 kg	m = 163.9 kg	m = 185.6 kg
Mass with lower tower part	m <sub>tot</sub> $\cong$ 126.4 kg	m <sub>tot</sub> = 255.7 kg	m <sub>tot</sub> = 277.4 kg
Starting wind speed	V <sub>start</sub> = 3.3 m/s	V <sub>start</sub> = 2.6 m/s	V <sub>start</sub> = 2.9 m/s
Cut in wind speed (if started)	V <sub>cut in</sub> = 2.2 m/s	V <sub>cut in</sub> = 2 m/s	V <sub>cut in</sub> = 2.5 m/s
Rated wind speed	V <sub>rated</sub> = 11 m/s	V <sub>rated</sub> = 9.5 m/s	V <sub>rated</sub> = 10 m/s
Survival wind speed	V <sub>surv</sub> = 35 m/s	V <sub>surv</sub> = 35 m/s	V <sub>surv</sub> = 35 m/s
Nominal battery voltage	U = 24 V DC	U = 24 V DC	U = 48 V DC
Rectification generator	delta	star	star
Power at rated wind speed	P <sub>rated</sub> = 165 W	P <sub>rated</sub> = 550 W	P <sub>rated</sub> = 820 W
Report checking $\delta$ -V curve		KD 223 (-3.3D)	KD 304
Report rotor calculations	KD 222	KD 231	KD 303
Report generator measurements	KD 54	KD 200	KD 82 (5A)
Report tower calculations		KD 305 (4.1)	KD 305
Licence fee excluding VAT	€ 1,500	€ 2,500	€ 2,500

**table 1 VIRYA windmills with galvanised steel blades and mild steel head**

	<b>VIRYA-3</b>	<b>VIRYA-3B3</b>	<b>VIRYA-3.5</b>	<b>VIRYA-4.2</b>	<b>VIRYA-4.6B2</b>
Rotor diameter	D = 3 m	D = 3 m	D = 3.5 m	D = 4.2 m	D = 4.6 m
Number of blades	B = 2	B = 3	B = 2	B = 2	B = 2
Design tip speed ratio	$\lambda_d = 7$	$\lambda_d = 6.5$	$\lambda_d = 8$	$\lambda_d = 8$	$\lambda_d = 7.75$
Material rotor blades	hard wood	hard wood	hard wood	hard wood	hard wood
Material head	stainless steel	stainless steel	mild steel	mild steel	mild steel
Material vane blade	plywood	plywood	plywood	plywood	plywood
Gear ratio	i = 1	i = 1	i = 1	i = 1	i = 1
Rotor eccentricity	e = 0.26 m	e = 0.26 m	e = 0.3 m	e = 0.42 m	e = 0.44 m
Height tower pipe	H = 3 m	H = 3 m	H = 3 m		
Total tower height	H <sub>tot</sub> = 9.5 m	H <sub>tot</sub> = 9.5 m	H <sub>tot</sub> = 9.5 m	H <sub>tot</sub> = 12.2 m	H <sub>tot</sub> = 12.2 m
Number of legs and material lower tower part	four legs, angle iron	four legs, angle iron	four legs, angle iron	three legs, pipe	three legs, pipe
Mass with tower pipe only	m = 73.9 kg	m = 74.4 kg	m = 95 kg		
Mass with lower tower part	m <sub>tot</sub> = 165.7 kg	m <sub>tot</sub> = 166.2 kg	m <sub>tot</sub> = 186.8 kg	m <sub>tot</sub> = 315.7 kg	m <sub>tot</sub> = 361.4 kg
Starting wind speed	V <sub>start</sub> = 3.3 m/s	V <sub>start</sub> = 2.7 m/s	V <sub>start</sub> = 2.1 m/s	V <sub>start</sub> = 3.4 m/s	V <sub>start</sub> = 3.3 m/s
Cut in wind speed (if started)	V <sub>cut in</sub> = 2.7 m/s	V <sub>cut in</sub> = 2.7 m/s	V <sub>cut in</sub> = 3.6 m/s	V <sub>cut in</sub> = 3.0 m/s	V <sub>cut in</sub> = 3.4 m/s
Rated wind speed	V <sub>rated</sub> = 9.5 m/s	V <sub>rated</sub> = 9.5 m/s	V <sub>rated</sub> = 9.5 m/s	V <sub>rated</sub> = 9.5 m/s	V <sub>rated</sub> = 9.5 m/s
Survival wind speed	V <sub>surv</sub> = 35 m/s	V <sub>surv</sub> = 35 m/s	V <sub>surv</sub> = 35 m/s	V <sub>surv</sub> = 35 m/s	V <sub>surv</sub> = 35 m/s
Nominal battery voltage	U = 24 V DC	U = 24 V DC	U = 48 V DC	U = 48 V DC	U = 48/96 VDC
Rectification generator	star	star	star	star	star
Power at rated wind speed	P <sub>rated</sub> = 500 W	P <sub>rated</sub> = 500 W	P <sub>rated</sub> = 1075 W	P <sub>rated</sub> = 1100 W	P <sub>rated</sub> = 1700 W
Report checking $\delta$ -V curve	KD 213 (-4.2)	KD 213 (-4.2)	KD 213 (-4.2)	KD 213	KD 213 (-4.2)
Report rotor calculations	KD 241	KD 484	KD 589	KD 218	KD 584
Rep. generator measurements	KD 78	KD 78	Chinese folder	KD 200	KD 82 (-5A)
Report tower calculations	KD 305 (-4.1)	KD 305 (-4.1)	KD 305 (-4.1)	KD 216	KD 216
Licence fee excluding VAT	€ 2,000	€ 2,000	€ 2,000	€ 2,500	€ 2,500

**table 2 VIRYA windmills with hard wood blades**

	<b>VIRYA-1.25</b>	<b>VIRYA-1.825</b>	<b>VIRYA-2.68</b>	<b>VIRYA-3.18</b>
Rotor diameter	D = 1.25 m	D = 1.825 m	D = 2.68 m	D = 3.18 m
Number of blades	B = 2	B = 2	B = 2	B = 2
Design tip speed ratio	$\lambda_d = 4.5$	$\lambda_d = 5.25$	$\lambda_d = 5.25$	$\lambda_d = 7$
Material rotor blades	stainless steel	stainless steel	stainless steel	stainless steel
Material head	stainless steel	stainless steel	stainless steel	mild steel
Material vane blade	stainless steel	stainless steel	aluminium	plywood
Material for 11 W fluorescent lamp	aluminium			
Gear ratio	i = 1	i = 1	i = 1	i = 1
Rotor eccentricity	e = 0.11 m	e = 0.15 m	e = 0.23 m	e = 0.3 m
Height tower pipe	H = 2 m	H = 2 m	H = 2 m	H = 3 m
Total tower height		H <sub>tot</sub> = 7.8 m	H <sub>tot</sub> = 7.5 m	H <sub>tot</sub> = 9.5 m
Number of legs and material lower tower part		one tubular pipe	four legs angle iron	four legs, angle iron
Mass with tower pipe only	m = 15 kg	m = 25.2 kg	m = 55.8 kg	m = 97.6 kg
Mass with lower tower part		m = 105	m = 112.9	m <sub>tot</sub> = 189.4 kg
Starting wind speed	V <sub>start</sub> = 2.9 m/s	V <sub>start</sub> = 4.4 m/s	V <sub>start</sub> = 3.1 m/s	V <sub>start</sub> = 2.8 m/s
Cut in wind speed (if started)	V <sub>cut in</sub> = 2.7 m/s	V <sub>cut in</sub> = 3.2 m/s	V <sub>cut in</sub> = 2.7 m/s	V <sub>cut in</sub> = 3.7 m/s
Rated wind speed	V <sub>rated</sub> = 11 m/s	V <sub>rated</sub> = 11 m/s	V <sub>rated</sub> = 11 m/s	V <sub>rated</sub> = 11 m/s
V <sub>rated</sub> for 11 W fluorescent lamp	V <sub>rated</sub> = 8 m/s			
Survival wind speed	V <sub>surv</sub> = 35 m/s	V <sub>surv</sub> = 35 m/s	V <sub>surv</sub> = 35 m/s	V <sub>surv</sub> = 35 m/s
Nominal battery voltage	U = 24 V DC	U = 24 V DC	U = 24 V DC	U = 48 V DC
Voltage for 11 W fluorescent lamp	U = 61 – 259 V			
Rectification generator	delta	delta	delta	star
For 11 W fluorescent lamp	star			
Power at rated wind speed	P <sub>rated</sub> = 100 W	P <sub>rated</sub> = 260 W	P <sub>rated</sub> = 400 W	P <sub>rated</sub> = 1100 W
Power for 11 W fluorescent lamp	P <sub>rated</sub> = 11 W			
Report rotor calculations	KD 247	KD 393	KD 461	KD 590
Report generator measurements	KD 18 (4AP)	KD 54	KD 78	Chinese folder
Report tower calculations			KD 129	KD 305 (-4.1)
Licence fee excluding VAT	€ 1,000	€ 1,500	€ 2,000	€ 2,000

**table 3 VIRYA windmills with stainless steel blades and B = 2**

	<b>VIRYA-1.75</b>	<b>VIRYA-1.8</b>	<b>VIRYA-2.2S</b>
Rotor diameter	D = 1.75 m	D = 1.8 m	D = 2.2 m
Number of blades	B = 3	B = 3	B = 3
Design tip speed ratio	$\lambda_d = 4.5$	$\lambda_d = 4$	$\lambda_d = 4.5$
Material rotor blades	stainless steel	stainless steel	stainless steel
Material head	stainless steel	stainless steel	stainless steel
Material vane blade	stainless steel	stainless steel	stainless steel
Gear ratio	i = 1	i = 1	i = 1
Rotor eccentricity	e = 0.15 m	e = 0.15 m	e = 0.18 m
Height tower pipe	H = 2 m	H = 2 m	H = 2 m
Total tower height	H <sub>tot</sub> = 7.8 m	H <sub>tot</sub> = 7.8 m	H <sub>tot</sub> = 7.5 m
Number of legs and material lower tower part	one tubular pipe	one tubular pipe	four legs angle iron
Mass with tower pipe only	m = 26.6 kg	m = 27.2 kg	m = 40.5 kg
Mass with lower tower part	m = 106.4	m = 107	m = 97.6 kg
Starting wind speed	V <sub>start</sub> = 3 m/s	V <sub>start</sub> = 3.1 m/s	V <sub>start</sub> = 3.6 m/s
Cut in wind speed (if started)	V <sub>cut in</sub> = 3.4 m/s	V <sub>cut in</sub> = 2.4 m/s	V <sub>cut in</sub> = 2.6 m/s
Rated wind speed	V <sub>rated</sub> = 11 m/s	V <sub>rated</sub> = 11 m/s	V <sub>rated</sub> = 11 m/s
Survival wind speed	V <sub>surv</sub> = 35 m/s	V <sub>surv</sub> = 35 m/s	V <sub>surv</sub> = 35 m/s
Nominal battery voltage	U = 24 V DC	U = 24 V DC	U = 24 V DC
Rectification generator	delta	star	delta
Power at rated wind speed	P <sub>rated</sub> = 260 W	P <sub>rated</sub> = 190 W	P <sub>rated</sub> = 290 W
Report rotor calculations	KD 482	KD 497	KD 115
Report generator measurements	KD 54	KD 54	KD 55
Report tower calculations			KD 129
Licence fee excluding VAT	€ 1,500	€ 1,500	€ 2,000

**table 4 VIRYA windmills with stainless steel blades and stainless steel head and B = 3**

	<b>VIRYA-1</b>	<b>VIRYA-1.04 + -0.98</b>	<b>VIRYA-1.25AF</b>	<b>VIRYA-1.36</b>	<b>VIRYA-1.66</b>	<b>VIRYA-1.81</b>
Rotor diameter	D = 1 m	D = 1.04 m	D = 1.25 m	D = 1.36 m	D = 1.66 m	D = 1.81 m
Number of blades	B = 2	B = 3	B = 2	B = 2	B = 3	B = 2
Design tip speed ratio	$\lambda_d = 4.25$	$\lambda_d = 3.5$	$\lambda_d = 4.75$	$\lambda_d = 5$	$\lambda_d = 4.5$	$\lambda_d = 5$
Generator	axial flux 8-pole, 3-phase	hub dynamo 28-pole, 1-phase	axial flux 8-pole, 3-phase	axial flux 8-pole, 3-phase	axial flux 12-pole, 3-phase	axial flux 8-pole, 3-phase
Material rotor blades	aluminium	aluminium	stainless steel	stainless steel	stainless steel	stainless steel
Material head	stainless steel	stainless steel	stainless steel	stainless steel	stainless steel	stainless steel
Material and thickness vane blade	aluminium 2 mm	aluminium 1.5 mm	aluminium 2 mm	aluminium 2 mm	aluminium 2 mm	stainless steel 1 mm
Gear ratio	i = 1	i = 1	i = 1	i = 1	i = 1	i = 1
Rotor eccentricity	e = 0.09 m	e = 0.09 m	e = 0.11 m	e = 0.12 m	e = 0.15 m	e = 0.15 m
Height tower pipe	H = 1 m	H = 1 m	H = 2 m	H = 2 m	H = 2 m	H = 2 m
Total tower height	H <sub>tot</sub> = 3.7 m	H <sub>tot</sub> = 3.7 m	H <sub>tot</sub> = 4.7 m	H <sub>tot</sub> = 4.7 m	H <sub>tot</sub> = 4.7 m	H <sub>tot</sub> = 7.5 m
Number of legs and material lower tower part	one square wooden pole	one square wooden pole	one square wooden pole	one square wooden pole	one square wooden pole	free standing tubular tower
Mass with tower pipe only	m = 4.8 kg	m = 4.85 kg	m = 12.1 kg	m = 13.6 kg	m = 22 kg	m = 25 kg
Starting wind speed	V <sub>start</sub> = 2.5 m/s	V <sub>start</sub> = 2.6 m/s	V <sub>start</sub> = 2.5 m/s	V <sub>start</sub> = 2.4 m/s	V <sub>start</sub> = 2.3 m/s	V <sub>start</sub> = 2.6 m/s
Cut in wind speed (if started)	V <sub>cut in</sub> = 2.5 m/s	V <sub>cut in</sub> = 2 m/s	V <sub>cut in</sub> = 2.5 m/s	V <sub>cut in</sub> = 2.5 m/s	V <sub>cut in</sub> = 3 m/s	V <sub>cut in</sub> = 3 m/s
Rated wind speed	V <sub>rated</sub> = 9 m/s	V <sub>rated</sub> = 8 m/s	V <sub>rated</sub> = 9 m/s	V <sub>rated</sub> = 9 m/s	V <sub>rated</sub> = 9 m/s	V <sub>rated</sub> = 11 m/s
Survival wind speed	V <sub>surv</sub> = 30 m/s	V <sub>surv</sub> = 30 m/s	V <sub>surv</sub> = 30 m/s	V <sub>surv</sub> = 30 m/s	V <sub>surv</sub> = 30 m/s	V <sub>surv</sub> = 35 m/s
Nominal battery voltage	U = 12 V DC	U = 12 V DC	U = 12 V DC	U = 12 V DC	U = 12 V DC	U = 12 or 24 V DC
Rectification generator	3-phase star	1-phase	3-phase star	3-phase star	3-phase star	3-phase star
Power at rated wind speed	P <sub>rated</sub> = 33 W	P <sub>rated</sub> = 6 W	P <sub>rated</sub> = 50 W	P <sub>rated</sub> = 71 W	P <sub>rated</sub> = 130 W	P <sub>rated</sub> = 206 W
Report rotor calculations	KD 608	KD 518 + 615	KD 626	KD 571	KD 596	KD 631
Generator measurements	not yet performed	in KD 518	not yet performed	in KD 571	not yet performed	not yet performed
Licence fee excluding VAT	free via website	free via website	free via website	free via website	free via website (only rotor + generator)	free via website (only rotor + generator)

**table 5 VIRYA windmills with hub dynamo or axial flux generator and a free licence. For manual and drawings VIRYA-1.04, -1.36, -1.66 and -1.81 see website menu KD-reports at the bottom. For drawings VIRYA-1 see report KD 574. For drawings VIRYA-0.98 see report KD 615. For drawings VIRYA-1.25AF see report KD 626**

	<b>VIRYA-3.3S</b>
Rotor diameter	D = 3.3 m
Number of blades	B = 3
Design tip speed ratio	$\lambda_d = 4.5$
Material rotor blades	galvanised steel
Material spoke assembly, head and tower	mild steel
Material vane blade	plywood
Gear ratio	i = 1
Rotor eccentricity	e = 0.27 m
Tower height	H = 8.45 m
Mass including tower but excluding concrete	m = 190 kg
Starting wind speed	V <sub>start</sub> = 2.3 m/s
Cut in wind speed for water pumping	V <sub>cut in</sub> = 4.5 m/s
Cut in wind speed for 24 V battery charging	V <sub>cut in</sub> = 3 m/s
Rated wind speed	V <sub>rated</sub> = 11 m/s
Design wind speed for water pumping	V <sub>d</sub> = 6.9 m/s
Survival wind speed	V <sub>surv</sub> = 35 m/s
Nominal phase voltage for water pumping	U = 230 V AC
Nominal rectified voltage for battery charging	U = 24 V DC
Rectification generator for battery charging	star
Power at rated wind speed for 24 V battery charging	P <sub>rated</sub> = 600 W
Report checking $\delta$ -V curve safety system	KD 223
Report rotor calculations	KD 576
Report generator description	KD 560
Report tubular tower	KD 562
Licence fee excluding VAT	€ 2,000

**table 6 VIRYA windmill with galvanised steel blades and mild steel head for water pumping and battery charging**