Extended specification VIRYA windmills for battery charging and water pumping (3.3S).   A. Kragten, July 2015

	VIRYA-1.8D	VIRYA-3.8	VIRYA-4.1
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_{tot} = 8 m	H_{tot} = 9.5 m	H_{tot} = 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	$m_{tot} \cong$ 126.4 kg	m_{tot} = 255.7 kg	m_{tot} = 277.4 kg
Starting wind speed	V_{start} = 3.3 m/s	V_{start} = 2.6 m/s	V_{start} = 2.9 m/s
Cut in wind speed (if started)	$V_{cut\ in}$ = 2.2 m/s	$V_{cut\ in}$ = 2 m/s	$V_{cut\ in}$ = 2.5 m/s
Rated wind speed	V_{rated} = 11 m/s	V_{rated} = 9.5 m/s	V_{rated} = 10 m/s
Survival wind speed	V_{surv} = 35 m/s	V_{surv} = 35 m/s	V_{surv} = 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_{rated} = 165 W	P_{rated} = 550 W	P_{rated} = 820 W
Report checking δ-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

	VIRYA-3	VIRYA-3B3	VIRYA-3.5	VIRYA-4.2	VIRYA-4.6B2
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_{tot} = 9.5 m	H_{tot} = 9.5 m	H_{tot} = 9.5 m	H_{tot} = 12.2 m	H_{tot} = 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_{tot} = 165.7 kg	m_{tot} = 166.2 kg	m_{tot} = 186.8 kg	m_{tot} = 315.7 kg	m_{tot} = 361.4 kg
Starting wind speed	V_{start} = 3.3 m/s	V_{start} = 2.7 m/s	V_{start} = 2.1 m/s	V_{start} = 3.4 m/s	V_{start} = 3.3 m/s
Cut in wind speed (if started)	$V_{cut\ in}$ = 2.7 m/s	$V_{cut\ in}$ = 2.7 m/s	$V_{cut\ in}$ = 3.6 m/s	$V_{cut\ in}$ = 3.0 m/s	$V_{cut\ in}$ = 3.4 m/s
Rated wind speed	V_{rated} = 9.5 m/s	V_{rated} = 9.5 m/s	V_{rated} = 9.5 m/s	V_{rated} = 9.5 m/s	V_{rated} = 9.5 m/s
Survival wind speed	V_{surv} = 35 m/s	V_{surv} = 35 m/s	V_{surv} = 35 m/s	V_{surv} = 35 m/s	V_{surv} = 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_{rated} = 500 W	P_{rated} = 500 W	P_{rated} = 1075 W	P_{rated} = 1100 W	P_{rated} = 1700 W
Report checking δ-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

	VIRYA-1.25	VIRYA-1.825	VIRYA-2.68	VIRYA-3.18
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	λ_d = 4.5	λ_d = 5.25	λ_d = 5.25	λ_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 Material for 11 W fluorescent lamp	stainless steel aluminium	stainless steel	aluminium	plywood
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_{tot} = 7.8 m	H_{tot} = 7.5 m	H_{tot} = 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_{tot} = 189.4 kg
Starting wind speed	V_{start} = 2.9 m/s	V_{start} = 4.4 m/s	V_{start} = 3.1 m/s	V_{start} = 2.8 m/s
Cut in wind speed (if started)	$V_{cut\ in}$ = 2.7 m/s	$V_{cut\ in}$ = 3.2 m/s	$V_{cut\ in}$ = 2.7 m/s	$V_{cut\ in}$ = 3.7 m/s
Rated wind speed V_{rated} for 11 W fluorescent lamp	V_{rated} = 11 m/s V_{rated} = 8 m/s	V_{rated} = 11 m/s	V_{rated} = 11 m/s	V_{rated} = 11 m/s
Survival wind speed	V_{surv} = 35 m/s	V_{surv} = 35 m/s	V_{surv} = 35 m/s	V_{surv} = 35 m/s
Nominal battery voltage Voltage for 11 W fluorescent lamp	U = 24 V DC U = 61 – 259 V	U = 24 V DC	U = 24 V DC	U = 48 V DC
Rectification generator For 11 W fluorescent lamp	delta star	delta	delta	star
Power at rated wind speed Power for 11 W fluorescent lamp	P_{rated} = 100 W P_{rated} = 11 W	P_{rated} = 260 W	P_{rated} = 400 W	P_{rated} = 1100 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

	VIRYA-1.75	VIRYA-1.8	VIRYA-2.2S
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	λ_d = 4.5	λ_d = 4	λ_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_{tot} = 7.8 m	H_{tot} = 7.8 m	H_{tot} = 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_{start} = 3 m/s	V_{start} = 3.1 m/s	V_{start} = 3.6 m/s
Cut in wind speed (if started)	$V_{cut\ in}$ = 3.4 m/s	$V_{cut\ in}$ = 2.4 m/s	$V_{cut\ in}$ = 2.6 m/s
Rated wind speed	V_{rated} = 11 m/s	V_{rated} = 11 m/s	V_{rated} = 11 m/s
Survival wind speed	V_{surv} = 35 m/s	V_{surv} = 35 m/s	V_{surv} = 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_{rated} = 260 W	P_{rated} = 190 W	P_{rated} = 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

	VIRYA-1	**VIRYA-1.04**	**VIRYA-1.36**
Rotor diameter	D = 1 m	D = 1.04 m	D = 1.36 m
Number of blades	B = 2	B = 3	B = 2
Design tip speed ratio	$\lambda_d = 4.25$	$\lambda_d = 3.5$	$\lambda_d = 5$
Generator	axial flux 6-pole, 2-phase	hub dynamo 28-pole, 1-phase	axial flux 8-pole, 3-phase
Material rotor blades	aluminium	aluminium	stainless steel
Material head	stainless steel	stainless steel	stainless steel
Material and thickness vane blade	Aluminium 2 mm	Aluminium 1.5 mm	Aluminium 2 mm
Gear ratio	i = 1	i = 1	i = 1
Rotor eccentricity	e = 0.09 m	e = 0.09 m	e = 0.12 m
Height tower pipe	H = 1 m	H = 1 m	H = 2 m
Total tower height	H_{tot} = 3.7 m	H_{tot} = 3.7 m	H_{tot} = 4.7 m
Number of legs and material lower tower part	one square wooden pole	one square wooden pole	one square wooden pole
Mass with tower pipe only	m = 5.55 kg	m = 4.85 kg	m = 13.6 kg
Starting wind speed	V_{start} = 2.5 m/s	V_{start} = 2.6 m/s	V_{start} = 2.4 m/s
Cut in wind speed (if started)	$V_{cut\ in}$ = 2.5 m/s	$V_{cut\ in}$ = 2 m/s	$V_{cut\ in}$ = 2.5 m/s
Rated wind speed	V_{rated} = 10 m/s	V_{rated} = 8 m/s	V_{rated} = 10 m/s
Survival wind speed	V_{surv} = 30 m/s	V_{surv} = 30 m/s	V_{surv} = 35 m/s
Nominal battery voltage	U = 12 V DC	U = 12 V DC	U = 12 V DC
Rectification generator	2-phase star	1-phase	3-phase star
Power at rated wind speed	P_{rated} = 35 W	P_{rated} = 6 W	P_{rated} = 80 W
Report rotor calculations	KD 574	KD 518	KD 571
Generator measurements	in KD 574	in KD 518	in KD 571
Licence fee excluding VAT	free via website	free via website	free via website

table 5 VIRYA windmills with hub dynamo or axial flux generator and a free licence. For manual and drawings VIRYA-1.04 and VIRYA-1.36 see menu KD-reports at the bottom. For drawings VIRYA-1 see report KD 574.

	VIRYA-3.3S
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_{start} = 2.3 m/s
Cut in wind speed for water pumping	$V_{cut\ in}$ = 4.5 m/s
Cut in wind speed for 24 V battery charging	$V_{cut\ in}$ = 3 m/s
Rated wind speed	V_{rated} = 11 m/s
Design wind speed for water pumping	V_d = 6.9 m/s
Survival wind speed	V_{surv} = 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_{rated} = 600 W
Report checking δ-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 for 24 V battery charging