Small wind PV-curves Schoondijke

PV-curves of 7 small wind turbines
based on test results of Schoondijke, The Netherlands

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Summary

The PV-curves of 7 small wind turbines are calculated from the measurements gathered at open air test facility Schoondijke in the Netherlands.

The PV-curves are calculated from binned samples of the wind speed and energy yield. These samples had a sample frequency of once every 5 minutes. As a consequence of this procedure, the PV-curves are comparable to the PV-curves measured according to the IEC-61400 procedure up to a wind speed of approximately 10 m/s. Down times of the wind turbines are calculated from the % of time where the power output equals zero at a wind speed of 6 m/s or higher.

The PV-curves show sometimes high cut in wind speeds for urban applications and actual performances are not always what manufacturers claim. Down times of the wind turbines vary an order of magnitude.

Contents

Chapter 1

On the analysis

1.1 PV-curves calculation

The PV-curves are destilled from the measurements of the average energy yield per 5 minutes as a function of the wind speed, sampled once every 5 minutes. As a consequence, the power of the small wind turbines P is calculated from

$$P = E \times 12 \tag{1.1}$$

The power P is binned to bins of 0.5 [m/s]. The wind speed is taken as the bin centre.

The PV-curves are based on the measurements of the past two measurement years (Default), except for the Donqi and Raum:

Default (date/month/year): 8/4/2008-8/9/2010

Donqi (date/month/year): 27/5/2010-8/9/2010

Raum (date/month/year): 1/4/2009-1/4/2010

All measurements are used except those where P=0 [Watt] at V>6 [m/s]. It should be stressed that wind directions in line with the row of turbines and wind directions where the wind turbines are located downwind of the neighbouring buildings, are part of these measurements.

The result of the analysis is shown in graphs with the power P as a function of the wind speed V, these graphs thus show the so-called PV-curves of the small wind turbines. The error in the measurements is shown as error bars in the graphs. The error is calculated from the statistics of the measured variable (standard deviation, number of measurements). It should be stressed that any possible off-set in the measurements is not taken into account. Situations where P=0 [Watt] for V>6 [m/s] are counted and shown in a separate table as these situations are a measure for 'out of order'.

1.2 Interpretation of the results

One might expect discrepancies of the PV-curves from this measurement procedure compared to the PV-curves from the IEC-61400 certification measurement procedure. In order to qualitatively show the differences of the used procedure compared to the IEC procedure, the PV-curve of the Skystream based on the IEC-61400 procedure is shown as a solid line together with the PV-curve from the procedure followed in this report, shown as dots. The

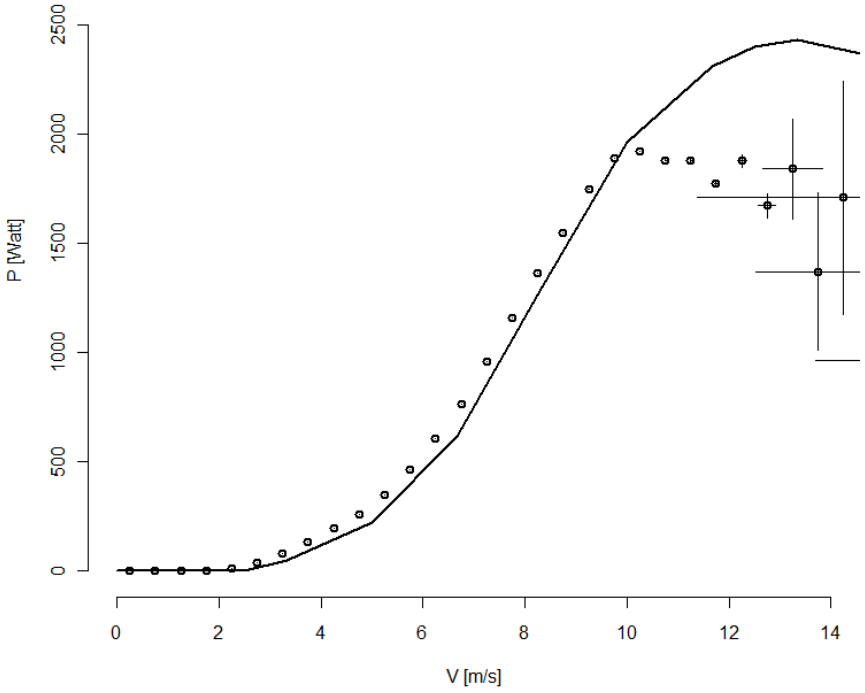

Figure 1.1: PV-curve Skystream.

differences are relatively small except for wind speeds above 10 [m/s].

The differences above 10 [m/s] are probably caused by the measurement method. The wind speed is sampled every 5 minutes. As a consequence, the samples of high wind speeds are likely to be taken during gusts and not during lulls as the latter requires unlikely high wind-speeds. In these gusts, the rotor RPM does not fit the wind speed because it takes a while before the flywheel of the rotor speeds up. We thus know that the measurements at high

winds speeds, say above 10 m/s, do not represent information that can be used to calculate an IEC-61400 like PV-curve. Instead the measurements above 10 m/s inform us on the effect of stalled rotor blades. A too low RPM results in a higher angle of attack of the incoming flow on the rotor blade, so that a too low RPM forces the blades towards stall.

Chapter 2

The results

2.1 Down time

The situations where P=0 [Watt] at V>6 [m/s] are counted. Suppose these situations are denoted as p6. Based on the measured wind speeds at Schoondijke (see [1]), a wind speed of 6 m/s or higher does occur approximately 10 % of the time so that the down time of the wind turbines in % of the total measurement time may be found with 10×p6. The down time of the turbines is shown in table 2.1.

Turbine	**Down time [%]**
Airdolphin	0.7
Ampair	11
Donqi	12
EnergyBall	11
Passaat	0.6
Raum	41
Skystream	0.9
WRE007	14

Table 2.1: Down time of the turbines calculated from 10×p6, where p6 is the % of time where P=0 [Watt] at V>6 [m/s].

It is likely that the wind turbines needed maintenance during the down time. The downtime can thus be interpreted as the % of time where maintenance is needed. It has to be mentioned however that Schoondijke is a test location so that the actual down time on real production sites may be less, certainly for the Raum and Donqi that are new on the test site.

2.2 PV-curves

The power curves calculated from the measurements are shown on the following pages in alphabetical order of the turbine names.

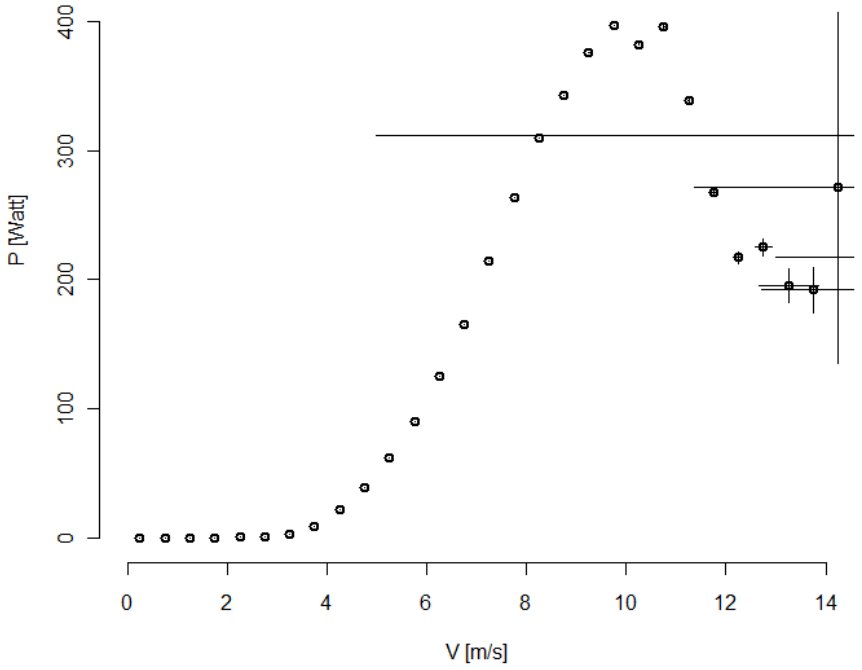

Figure 2.1: PV-curve Airdolphin.

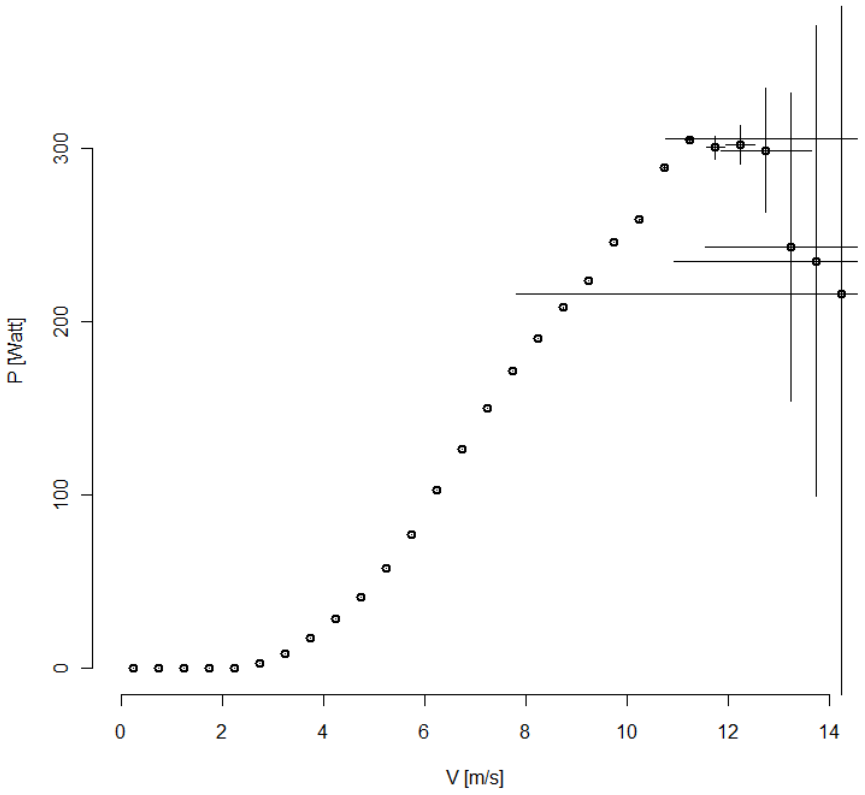

Figure 2.2: PV-curve Ampair.

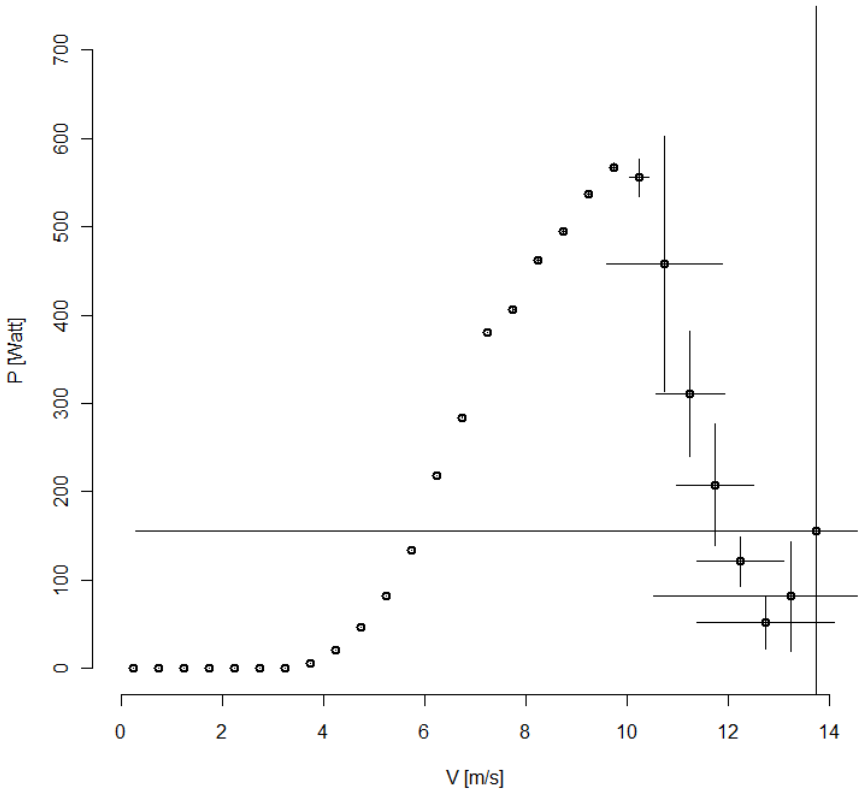

Figure 2.3: PV-curve Donqi.

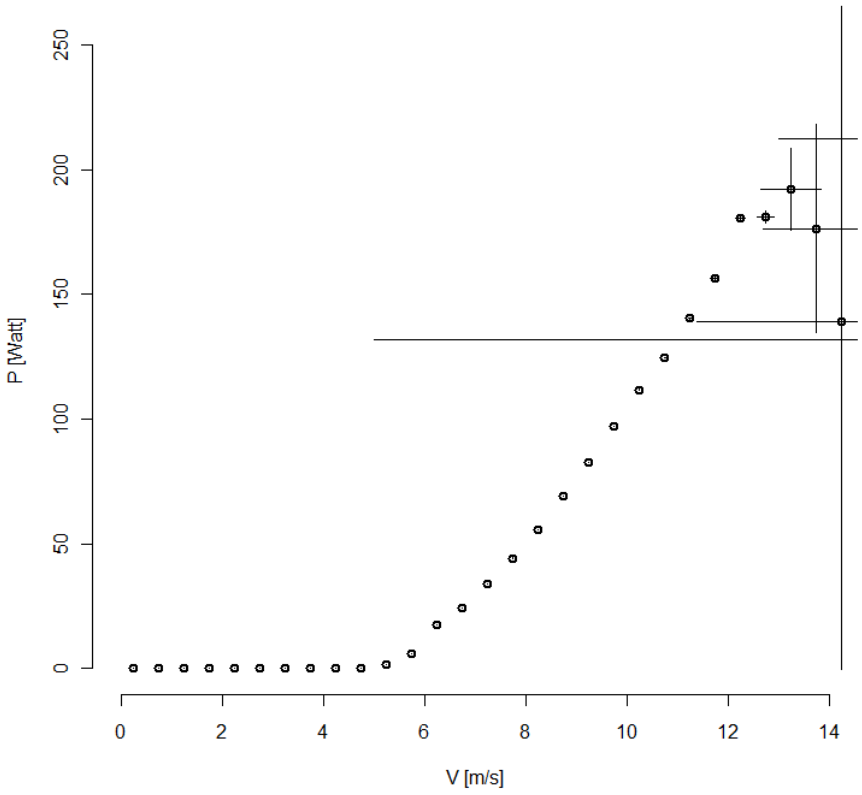

Figure 2.4: PV-curve EnergyBall.

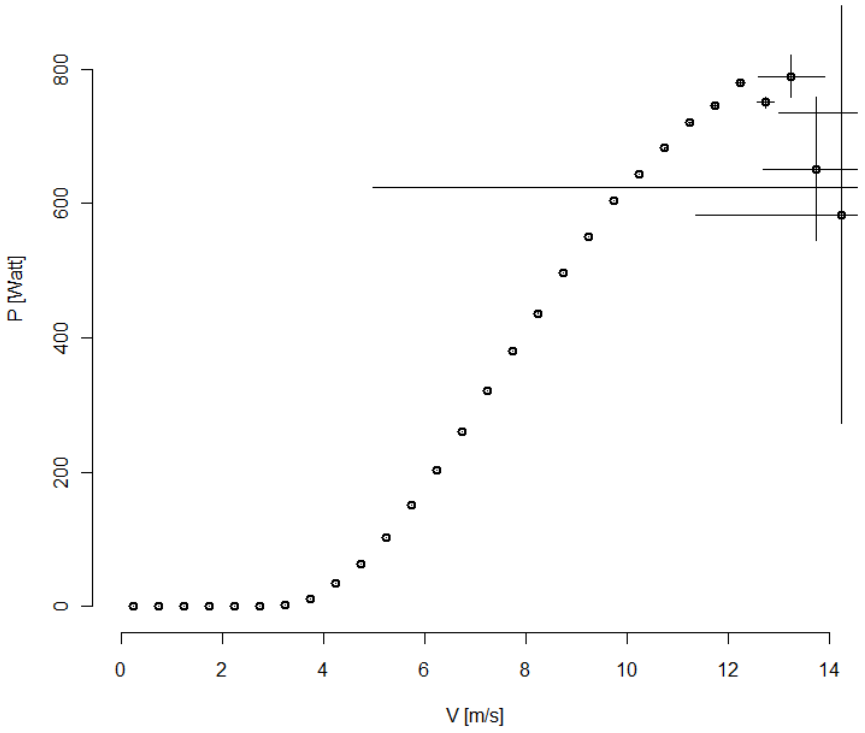

Figure 2.5: PV-curve Passaat.

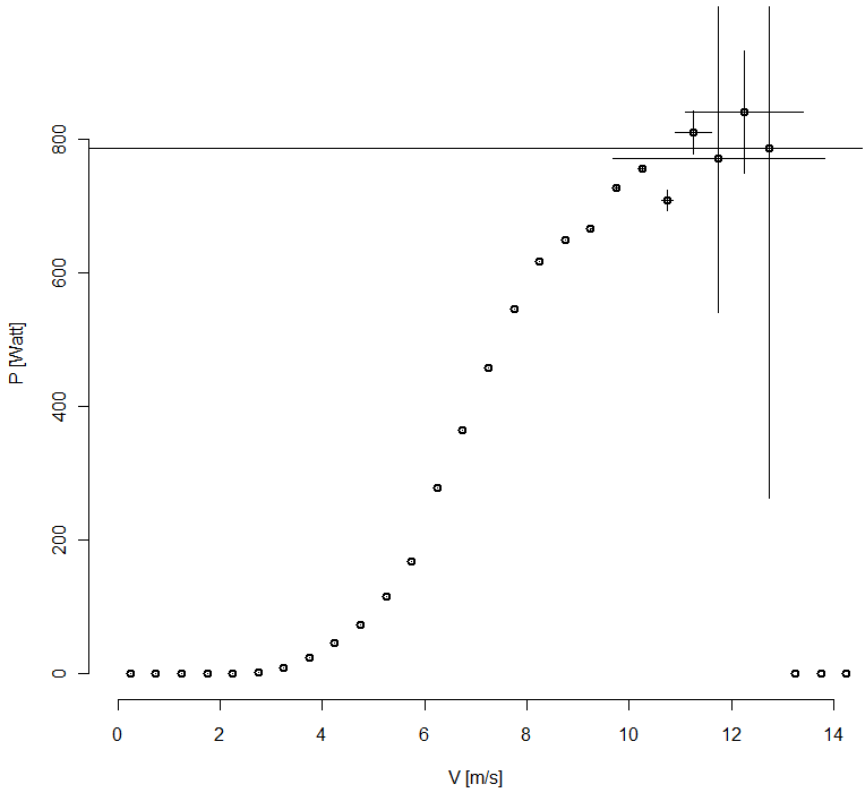

Figure 2.6: PV-curve Raum.

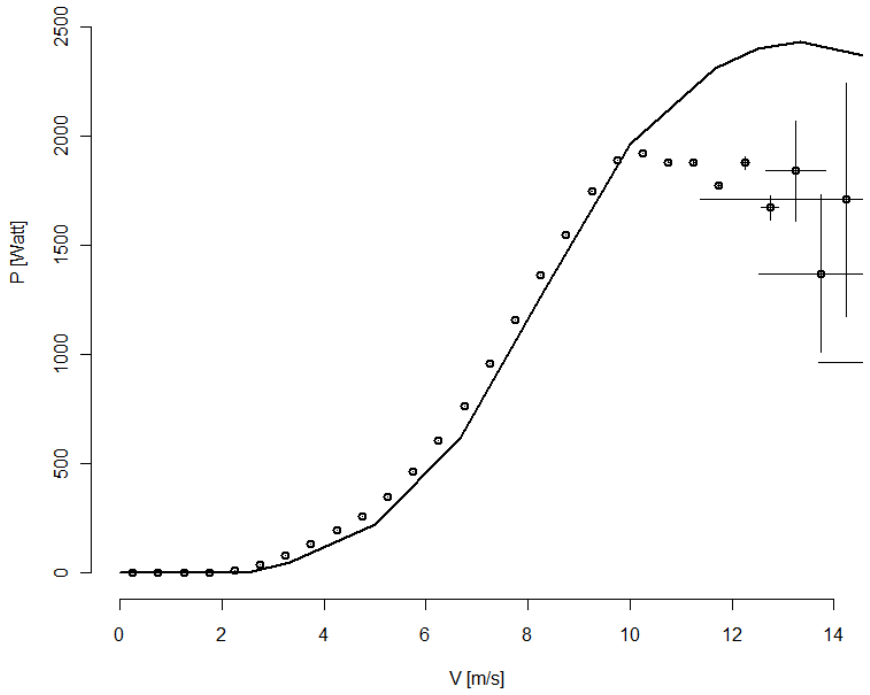

Figure 2.7: PV-curve Skystream. Dots: calculated from Schoondijke measurements. Solid line: calculated from IEC 61400 measurements.

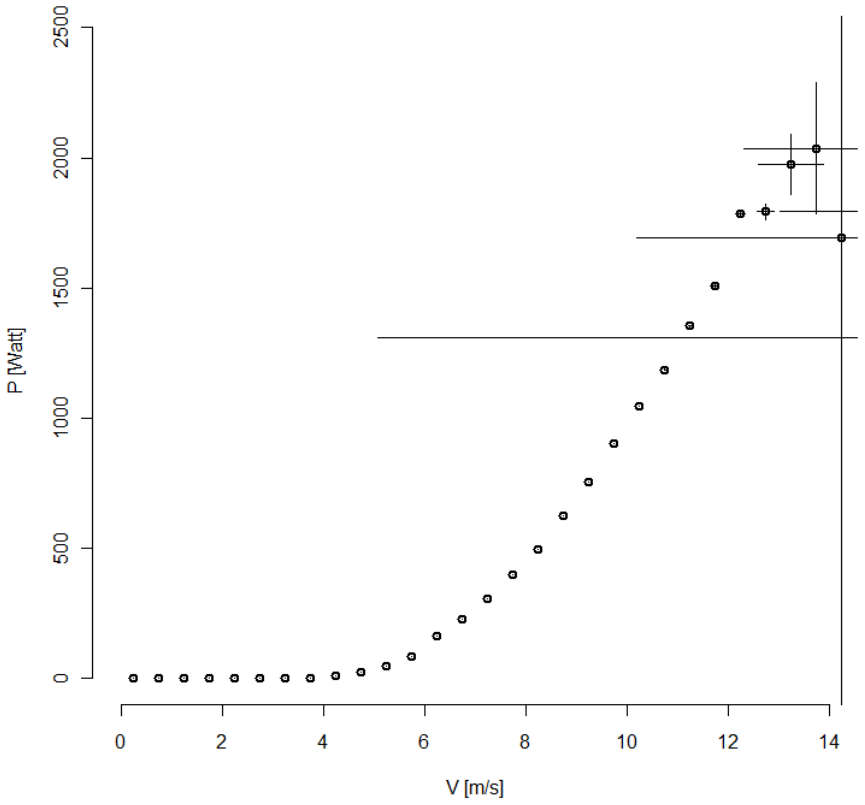

Figure 2.8: PV-curve WRE007.

Bibliography

[1] Mertens, S., **1ste Evaluatie meetresultaten testveld kleine windturbines Zeeland**, Ingreenious Rapport 0904000.R01, mei 2009