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Real-world tests of small wind turbines in Netherlands and the UK

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This is a guest post by Kris de Decker. Kris is editor of Low Tech Magazine. Rembrandt and I saw a somewhat similar story in the Dutch version of Low Tech Magazine, and Kris was kind enough to put together this story in English for us.

Photo by Jeroen Haringman

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The machines face two fundamental problems: there is not enough wind at low altitudes in a built-up environment, and the energy production of a wind turbine declines more than proportionately to the rotor diameter. Wind power rules, but small wind turbines are a swindle.

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12 Small Wind Turbines Tested in the Netherlands

The Dutch coastal province of Zeeland (a very windy place) placed twelve of these much hyped machines in a row on an open plain (picture above). Their energy yield was measured over a period of one year (April 1, 2008 - March 31, 2009). The average wind velocity during these 12 months was 3.8 metres per second (more on the wind speed later).

Three wind turbines broke. Find the disappointing results of the others below. (Original test results here, pdf in Dutch.)

- Energy Ball v100 (4,304 euro) : 73 kWh per year, corresponding to an average output of 8.3 watts
- Ampair 600 (8,925 euro) : 245 kWh per year or an average output of 28 watts
- Turby (21,350 euro) : 247 kWh per year or an average output of 28.1 watts
- Airdolphin (17,548 euro) : 393 kWh per year or an average output of 44.8 watts
- WRE 030 (29,512 euro) : 404 kWh per year or an average output of 46 watts
- WRE 060 (37,187 euro) : 485 kWh per year or an average output of 55.4 watts
- Passaat (9,239 euro) : 578 kWh per year or an average output of 66 watts
- Skystream (10,742 euro) : 2,109 kWh per year or an average power output of 240.7 watts
- Montana (18,508 euro) : 2,691 kWh per year or an average power output of 307 watts.

Keep in mind that these wind turbines would perform considerably worse in a built-up area.

47 windturbines to power a household

An average Dutch household consumes 3,400 kWh/year. Listed below is the amount of wind turbines required, and their total cost, to power a Dutch household entirely using wind energy:

- Energy Ball : 47 windmills (202,288 euro)
- Ampair : 14 windmills (124,950 euro)
- Turby : 14 windmills (298,900 euro)
- Airdolphin : 9 windmills (157,932 euro)
- WRE 030 : 9 windmills (265,608 euro)
- WRE 060 : 7 windmills (260,309 euro)
- Passaat : 6 windmills (55,434 euro)
- Skystream : 2 windmills (21,484 euro)
- Montana : 2 windmills (37,016 euro)

An average American household consumes almost 3 times as much electricity as a Dutch household. Simply multiply the above figures by three.

Rotor diameter

At first sight, the results seem to indicate that the design of the wind turbine matters. However, if you combine these figures with the rotor diameter, it becomes clear that the concept of small windmills is fundamentally flawed. The turbines that score best are simply the largest ones:

- Energy Ball : 1 metre
- Ampair : 1.7 metres
- Turby : 2 metres
- Airdolphin : 1.8 metres
- WRE 030 : 2.5 metres
- WRE 060 : 3.3 metres
- Passaat : 3.12 metres
- Skystream : 3.7 metres
- Montana : 5 metres

Wind turbines with a rotor diameter of 4 or 5 metres do not fit on most roofs, and are not easy to integrate into a built-up environment.

Size matters

Dutch wind energy expert Jaap Langenbach notes that close to the test site stands a (relatively) large wind turbine with a rotor diameter of 18 metres. It delivers 143,000 kWh per year, or an average power output of 16,324 watts. It can power 42 Dutch households. This large wind turbine costs only slightly more than all small wind turbines combined (17 percent more, to be exact, or 190,000 euro), but it delivers almost 20 times as much energy. This brings the cost down to 4,523 euro per household, which is 8 times more economical than the best performing small wind turbine (and 45 times cheaper than the worst performing small wind turbine).

If you double the rotor diameter of a wind turbine, the blades sweep an area that is four times as large. Material costs double, but the yield multiplies by four. The larger the rotor diameter, the more energy you get for your money, and for the energy invested. And the other way around, of course.

Doubts on the wind speed

The test results described above may give a too rosy picture of the performance of the machines. Following the publication of the results, some Dutch energy experts expressed their doubts regarding the measured average wind speed of 3.8 metres per second. After all, according to the wind map of the Netherlands, the average wind speed in Zeeland (at a height of ten metres) is 6 metres per second.

Jeroen Haringman determined that the measurements of other wind turbines in the same area over the same period was slightly higher than average. Jeroen van Agt reported that a weather station of the Dutch meteorological service, located 14 kilometres from the test site, measured a wind speed of 6 metres per second. Confronted with this information, the organizers of the test answered that the reported wind speed at the test site was "only indicative". If the wind speed at the location was indeed higher than 3.7 metres per second, then the performance of the machines is seriously overstated.

26 Small Windturbines Tested in the UK

A real-world test of 26 small wind turbines in the UK followed a different approach and is therefore an interesting addition to the results obtained in the Netherlands. The Warwick Wind Trials Project collected information on the electricity production of 5 different machines at 26 locations throughout the UK, from October 2007 to October 2008. The results were published in January 2009.

The machines were placed in a built-up environment. Half were attached to the facade or to the roof of single-family dwellings; the other half were attached to the roofs of apartment buildings. Unlike to the Dutch test, the intention was not to investigate how the machines operate with respect to one another, but how well or poorly small wind turbines work in a specific environment.

The maximum output of the turbines in the test according to the manufacturer were as follows:

- Ampair 600 230 (600 watts)
- Eclectic Stealth Gen 400 (1.000 watts)
- Zephyr Air Dolphin Z1000 (400 watts)
- Windsave WS 1000 (1.000 watts)
- Windsave WS 1200 (1.250 watts)
- Swift (1.500 watts)

78 kWh per year

The average electricity production of all 26 machines amounted to 78 kWh per year per wind turbine. This corresponds to an average output of 8.9 watts. This means that the turbines achieved on average less than 1% (actually 0.85%) of the maximum ouput stated by the manufacturers. For large wind turbines, the percentage of the maximum output achieved was between 10% and 30%. As mentioned above, half of the small wind turbines were placed on tops of apartment buildings.

Technical problems and damage

Ignoring the time that the machines were out of service due to technical problems or maintenance, the average yield rises to 230 kWh per year (or an average output of 26 watts). In this case, the machines achieve 4.15% of their maximum output (0.29% to 16.54%, depending on the location). Of course, this is a theoretical figure, since technical problems and maintenance do have a real influence on performance. Unlike solar panels, wind turbines consist of moving parts.

Two machines lost a sail, one machine lost its tail. These are not exactly desirable properties in a built-up environment. One turbine damaged the facade of a house (the fault of the installer, not the manufacturer).

Location matters

The best performing machine, mounted on top of a 45 metre high appartment building located on a hill, delivered 869 kWh per year (an average output of 99 watts). The worst performing machine, attached to the facade of a single-family dwelling, delivered 15 kWh per year (an average output of 1.7 watts). These results clearly indicate that the location is of decisive importance. The best placed turbines deliver as much electricity in one month as other turbines deliver in the course of a full year.

Noise pollution

Unfortunately, the best performing machines had to be shut down because the residents complained about noise pollution. Noise pollution was an unexpected problem.

Electricity consumption & embodied energy

The UK study also gives figures for the electricity consumption of the electronics used in the wind turbines. On average, this averages only 29 kWh per wind turbine per year (varying from 3 kWh to 136 kWh per year, depending on the machine). This means that some of the small wind turbines consume more electricity than they deliver. And then we are not even talking about the energy required to produce the machines: according to a report by the UK Carbon Trust, Small-scale wind energy: Policy insights and practical guidance, wind turbines in urban environments will almost always have an energy payback of more than 20 years. The warranty of most small wind turbines is 2 to 5 years.

The UK report warns that the aggressive and misleading marketing of the manufacturers, combined with the gullibility of the consumers and the authorities, might damage the reputation of wind energy - including the image of large wind turbines, which do have an attractive electricity production and payback time.

Articles from Low Tech Magazine on Related Subjects

http://www.lowtechmagazine.com/2009/04/small-windmills-test-results.html

http://www.lowtechmagazine.com/2008/09/urban-windmills.html

http://www.lowtechmagazine.be/2009/05/testresultaten-kleine-windturbines.html

http://www.lowtechmagazine.be/2008/07/energy-ball.html