FURTHER DEVOLOPMENT OF THE WIND ENERGY CONVERTER MoWEC FOR STAND ALONE USE

H. Irps, A. I. Omara

Federal Agricultural Research Center (FAL), Institute of Production Engineering and Building Research, Bundesallee 50, D-38116 Braunschweig, Germany, hartwig.irps@fal.de

Abstract - Wind energy is one of the most important sources of renewable energy. In areas with adequate mid-level wind speeds, the use of environmentally neutral wind power can reduce fossil energy fuels. Disadvantages include the minimal energy concentration and the irregular availability. For this reason, multivalent energy systems with preferential use of renewable energy will be built for future use.
Wind power facilities with large performance capabilities are built as permanently constructed facilities for static reasons. This type of construction with a permanent foundation, tower, rotor, rotor shaft, gear and generator has generated performance into the megawatt level in its technical development to date.
Since 2002, as an enhancement to the well-known installed wind power facilities, the concept of a **mo**bile **w**ind **e**nergy **c**onverter – in abbreviation **MoWEC** - has been implemented constructively in the German Institute of Production Engineering and Building Research and further tested and developed under practical conditions. The MoWEC is planned as an easy to handle wind energy technology for entire rural areas. Priority is implementation in stand alone farms.
The MoWEC1 was designed with two three-blade rotors running in opposite directions and with a yaw drive, which has its travel path on a locally fixed portable frame. The work has included the design and test of a Lee-wind wheel for the MoWEC in stand alone applications. Also the power curve of the MoWEC1 was measured.
The bivalent MoWEC2 shall be tested in 2004. In opposite to MoWEC1, here the yaw drive is also the portable frame. If there is a lack of wind velocity the MoWEC2-generator can be driven by an installed diesel-motor.
When research is concluded, the mobile wind power plants shall be made available in rural areas. Because the portable frame the user can purchase, rent or lease the MoWEC system. The installed power depends on the demand, e.g. until 30 Kilowatts.
Dr. Irps is the chief designer of the MoWEC. The guest scientist Mr. Omara from Egypt has made developments of the MoWEC yaw drive system (Lee wind wheel) and evaluated the MoWEC1 power curve as part of his graduation at the University Rostock, Department of Agricultural Engineering, Germany.

KEYWORDS: Wind energy converter, mobile wind energy converter, MoWEC, wind energy plant, wind heating system, wind pump, permanent-magnet synchronous generator, Lee-wind wheel, fantail.

PRINCIPLE of MoWEC

<u>MoWEC is constructed for one, two or more rotors</u>. The type of the used rotor is open to free choice according the demand, and can either use drag force or lift force. Figure 1 shows the basic principle of the MoWEC. The tower with the power loading rotor is always located in the downwind position at the turning point.

Wind energy plants with a horizontal axle needs a yaw drive system that turns the one or more rotor(s) according the actual wind direction. Also the rotor(s) with fixed wings according the stall regulation must be yawed on stormy weather. Figure 2 explained in which direction the gyro forces works. The MoWEC1 prototype has had two rotors where the rotations are in opposite direction. That is a contribution to compensate some of the anticipated gyro forces.

STAND ALONE USE

Wind energy plants in stand alone use can not need the public grid as energy store for the movement of the yaw drive frame. Small wind power plants – in maximum until nearly one kW – are often constructed with wind vanes. But because the MoWEC-prototype is designed for higher performances we decided to install the simple technique of a Lee-wind wheel, e.g. well-known also from historic windmills with fantails.

Theoretical studies results in a Lee-wind wheel with eight blades and an outer diameter of 1.50 m. In a wind tunnel experiment the optimal blade angle φ was determined with 22.5 °. Furthermore was shown, that the reduction ratio rw2 = 82.64:1 should be installed to drive reliable the yaw drive of the MoWEC1, which has then a total reduction ratio of 1371:1. Figure 3 shows the Lee-wind wheel inside the wind tunnel; on left side in the opened wind tunnel with $\theta \approx 40°$ and on right side inside the wind tunnel with $\theta = 0°$. The latter is the normal working position until the rated MoWEC-power. Figure 4 shows the Lee-wind wheel results with the cut in wind speed v_1, the required time t to lift the weight of 588.6 N one metre high and the power coefficient C_{pm} of the Lee-wind wheel in the choiced installation. On stormy weather θ changes from 10° to 90° to provide the yaw drive wheel with sufficient power in order to reduce the square metres of the main MoWEC-rotors via turning.

POWER CURVE

The power curve was measured in a field test with a permanent-magnet synchronous generator, which reaches 9.0 kW/400 V by 540 rpm and 10.6 kW/50 Hz by 600 rpm. A speed of 600 rpm has had a power output of 13.66 kW. This generator was choices to operate also in MoWEC2 with one rotor in the 2004. MoWEC1 has had two rotors (each 10 kW). So that we could measure the power curve until the rated power of the generator. Figure 5 shows three power curves in relation to the wind velocity. First the wind power, second the extrapolated MoWEC1 power with the total average power coefficient of Cpt = 0.32 and third the measured power curve. The stall rotor diameter was 7.10 m each and the hub heights 6.45 m.

FUTURE: In 2004 we will test the MoWEC2 (see Figure 7, here without diesel engine) with one rotor and a diesel engine. This bivalent system – shown in 3D-graph - can produce use energy also in times without sufficient wind velocities. With MoWEC1 and MoWEC2 (see Figure 6) we can recommend the construction and utilisation of mobile wind energy converters for rural areas, mainly with more than one rotor per system. For the kind of use energy equipment, please see Figure 1. Cooperation among international users is being sought.

REFERENCES. e.g. international:

Irps, H. The construction of the mobile wind energy plant MoWEC, ASAE paper in Chicago, USA (2002/4023 CD-ROM).

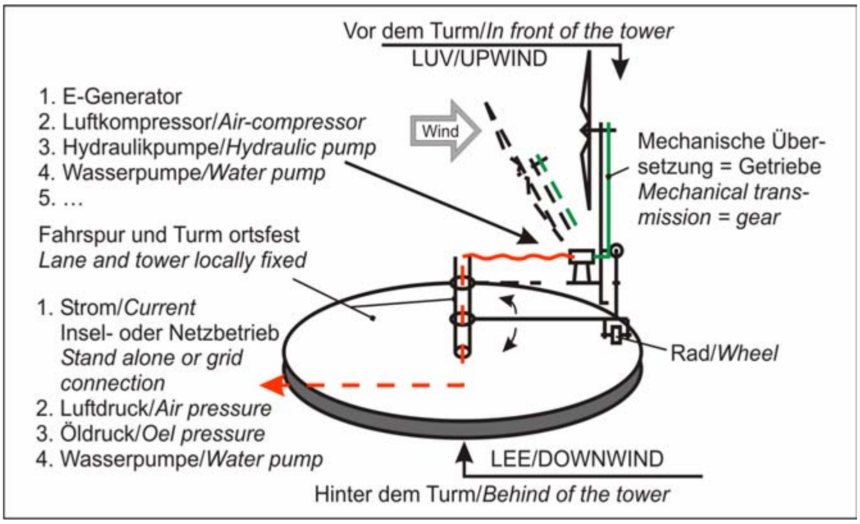

Figure 1: Downwind construction of the MoWEC rotors.

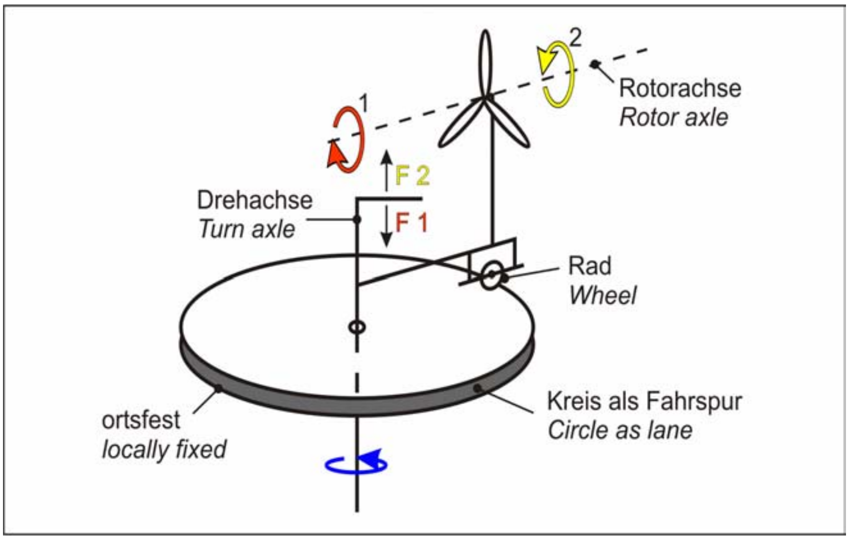

Figure 2: Forces on the yaw drive.

 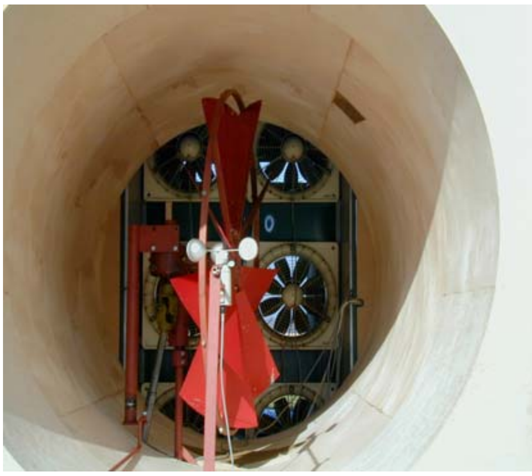

Figure 3, Figure 4: Lee-wind wheel inside the wind tunnel.

Table I: Results. Lee-wind wheel connected via gear in order to lift a weight of 588.6 N (equal the needed force to move the MoWEC1 yaw drive frame).

Angle between wind wheel and wind direction **θ**	Cut-in wind speed, required time and power coefficient v_1 & t & C_{pm}	Wind wheel blades angle φ							
		φ = 15°		**φ = 22.5°**		φ = 35°		φ = 45°	
		rw1 56.82:1	**rw2** 82.64:1	**rw1** 56.82:1	**rw2** 82.64:1	**rw1** 56.82:1	**rw2** 82.64:1	**rw1** 56.82:1	**rw2** 82.64:1
θ = 90°	v_1 [m/s] t [min] C_{pm} [%]	2.60 7.50 6.90	2.30 17.80 4.20	2.60 12.33 4.20	**2.60 8.50 6.10**	2.60 12.48 4.20	2.70 12.30 3.80	3.30 8.07 3.10	2.90 13.53 2.80
θ = 30°	v_1 [m/s] t [min] C_{pm} [%]	6.50 7.28 0.50	5.0 21.0 0.3	5.50 10.83 0.50	**4.70 16.47 0.50**	5.0 15.0 0.5	4.70 23.55 0.40	5.62 16.50 0.30	5.70 22.0 0.20
θ = 20°	v_1 [m/s] t [min] C_{pm} [%]	- - -	8.00 16.05 0.10	7.50 18.67 0.10	**6.90 15.33 0.20**	7.90 8.92 0.20	6.90 18.75 0.10	7.96 11.50 0.10	7.00 20.58 0.10
θ = 10°	v_1 [m/s] t [min] C_{pm} [%]	- - -	- - -	- - -	**8.20 32.00 0.10**	- - -	- - -	- - -	- - -

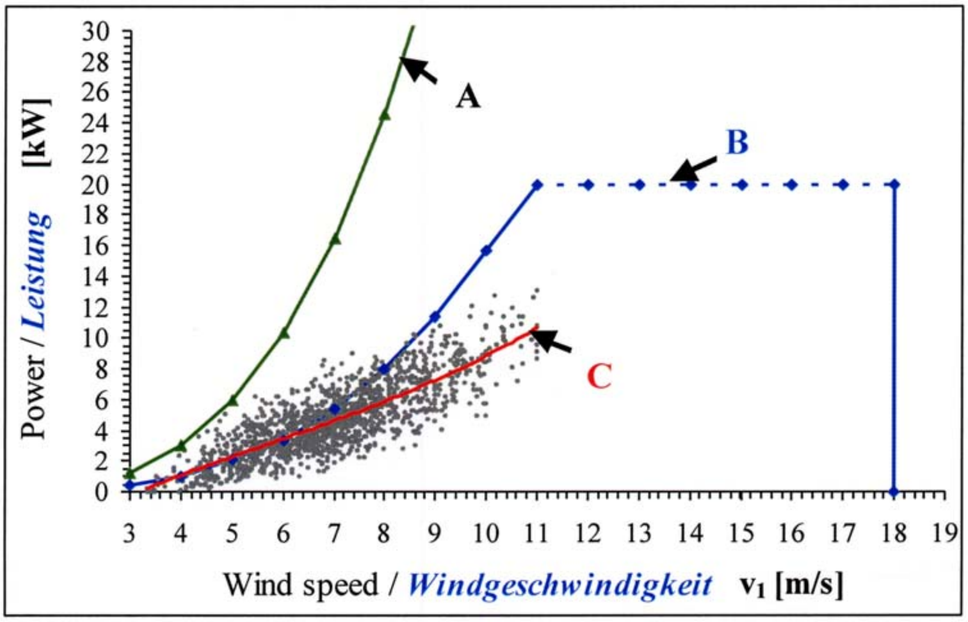

Figure 5: MoWEC 1 power curve: **A** = wind power; **B** = extrapolated MoWEC1 power curve with 2 rotors and total Cpt = 0.32; **C** = measured MoWEC1 power curve. Each rotor has had 40 m².

Figure 6: Photo of the MoWEC1 with Lee-wind wheel

Figure 7: Drawing of MoWEC2

Figure 8: Working and transport position of the MoWEC2. Bivalent with diesel motor. For use energy application see Figure 1.Test in 2004. Street- und container transport.