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# NEUWERK WINDMILL POWER GENERATION PLANT

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Representatives of the office of the VDEW (German Electric Power Industry /322*
Association) and of the editorial department recently had occasion to tour the North Sea island of Neuwerk. Since the only windmill power generation plant currently in the public power supply service is situated here, a fairly thorough description of the plant and its integration in the electric power supply system of the island should be of interest.[1]

## Situation

A person leaving the mouth of the Elbe by sea or one standing on the shore at the North Sea spa of Cuxhaven-Duhnen can, when visibility is good, make out the island of Neuwerk off the mainland to the northwest, with its landmark, the huge lighthouse. At ebb tide the island can be reached on foot across the Watt [flats] or in fording vehicles with high axles (Figure 1).

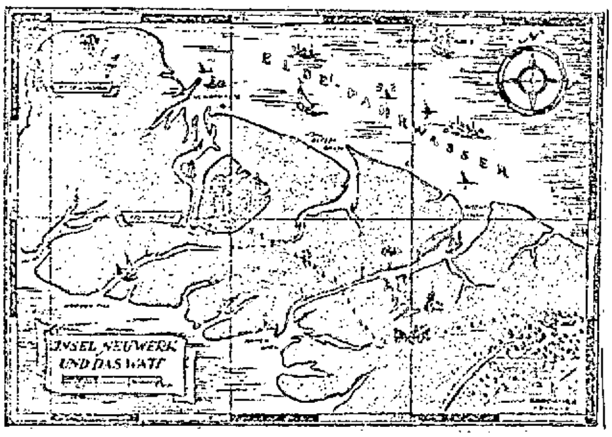

Figure 1. The Island of Neuwerk in the Wattenmeer.

Besides the lighthouse, an inn, several dwellings, and farms for agricultural exploitation of the fertile green lands are on the island. But the distance from the mainland is great enough to prevent supply of the island with power economically by means of a cable line in the overland grid of the regional electric power company. In addition, there is a particularly

*Numbers in the margin indicate pagination in the foreign text.

[1]The author should like to take this opportunity to express his great gratitude to the management and the Cuxhaven branch of the Ueberlandwerk Nordhannover Aktiengesselschaft in Bremen for making this study trip possible.

heavy demand as regards power supply precisely for a sea mark, and this demand can be met in general only by at least two mutually independent sources of power.

Particular consideration has been given to the matter of dependability of power supply on Neuwerk.

Power Generation Plants

The following units are installed at the direct-current power generation plant on the island:

1 diesel unit (I), 12 kw, 230 to 320 v, 950 rpm;

1 diesel unit (II), 37 kw, 230 to 320 v, 1,000 rpm;

1 storage battery, 644 Ah, 126 cells, 40 regulating cells.

Meteorological observations over a period of years have shown that the wind conditions on the North Sea coast are among the most favorable in Germany for the exploitation of wind power. Only 20% of all days have weather characterized by light winds; gale-force winds prevail on almost another 20% of all days. The mean wind velocity is between 5.5 and 6.5 meters per second. The prevailing wind direction in the Deutsche Bucht [German Bay] is southwesterly. Thus it was obvious that a windmill power generation plant should be built on this spot in the Wattenmeer favored by its isolated location, with the simultaneous object of gaining experience with this source of power which has not yet undergone practical testing in the public power supply system. After a smaller wind wheel had reached the point of working satisfactorily after lengthy operation, late in the summer of 1949 the plant was replaced by a more efficient universal wind motor, which with its tower 20 meters high and three-vane wind wheel has become another landmark of the island of Neuwerk (Figure 2).

Windmill Power Generation Plant

On 12 September 1949, after a two-week installation period, the universal wind motor, bearing the model designation "Nordwind 100/15", started operation.[2] /323

[2]The planning and design of the plant were under the direction of Dipl.-Eng. D. R. Stein. The project group consisted of Eng. H. Evers (chief designer), Eng. W. Baerenz (designer), Eng. Tielcke (Aerodynamic layout), and Master Miller R. Triller (technical consultant). Installation and start-up were directed by Dipl.-Eng. F. Villinger. The manufacturing firm is Nordwind GmbH., Porta Westfalica, which recently merged with Allgaier, Uhingen/Wuertt.

The following are its characteristics:

- guy trellis mast with hub of wind wheel 20 meters above the ground;
- three-vane wind wheel 15 meters in diameter with aerodynamic fan brake;
- self-actuated regulating device with auxiliary wind wheel;
- power transmission from wind wheel head through vertical shaft, bevel gearing, and drive belt transmission to generator at bottom of tower;
- rated output at v = 6.5 m/sec ... 11 kw;
  at v = 8.0 m/sec ... 18 kw;
- maximum speed of vane 61 rpm;
- beginning of regulation at 8 to 9 m/sec;
- switching of at approximately 14 m/sec;
- operating speed at

| | | | | | | |
|---|---|---|---|---|---|---|
| v | m/sec | 4 | 5 | 6 | 7 | 8 |
| n | rpm | 45 | 48 | 50 | 53 | 55 |
| u/v | (operating speed) | 8.84 | 7.54 | 6.54 | 5.94 | 5.40 |

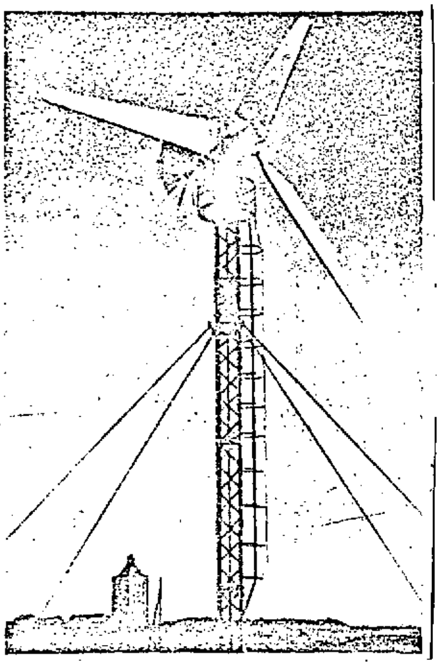

Figure 2. Nordwind Universal Wind Motor, Model 100/15, in Front of the Lighthouse on Neuwerk Island.

Mounting the generator at the foot of the tower reduces the weight of the head and presents the advantage that the generator can be inspected constantly without the need for ascending the tower and can be serviced easily. The limits of this design in further development of windmill power generation plants up to greater output and higher towers are quite obvious, however. The gearing on the mast is fully encapsulated and operates in an oil bath, so that, given trouble-free operation, only seldom will there by any need to go up to the gallery or a folding scaffold below the wind wheel shaft.

Regulating devices. The main regulating element is a self-actuating regulating device effecting smooth adjustment of the wind wheel within the range of regulation. It starts operating and wind velocities of 8 m/sec and higher, and as the wind becomes stronger rotates the wind wheel away from the wind, an output corresponding to 8 m/sec continuing to be taken from the wind. At approximately 14 m/sec the wind wheel is turned entirely away from the wind, no longer presenting any working surface to it. As the wind velocity diminishes, the wind wheel is turned back into the wind by a regulation process in the opposite direction.

Automatic regulation is initiated by an arrangement whereunder a static plate, which up to 8 m/sec holds a spring vertical to the direction of the wind, is forced to the side as the wind increases and as it does rotates an auxiliary wind wheel into the wind. Its initial rotary movement now triggers swivelling of the main wind wheel (Figure 3).

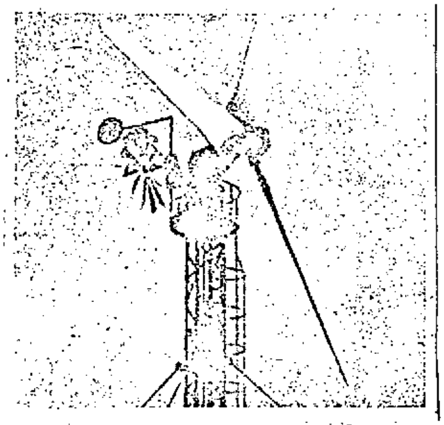

Figure 3. Regulating Device in Gale Position.

Dangerous effects from brief squalls, wide load fluctuations, or any failure of the regulating device which might cause racing of the wind wheel are prevented by an aerodynamic fan brake (storm safety). It consists of a centrifugal governor in the hub of the wind wheel (Figure 4) and effects twisting of the outer third of the vane toward the blade angle of the solid portion of the vane until the torque is eliminated. This safety measure proved its value on 1 December 1950, when the highest wind velocity recorded since the beginning of operation, 40 m/sec (corresponding to 144 km/hr) was measured, without any damage to the windmill power generation plant. On the Beaufort scale wind velocities greater than 29 m/sec are classified as hurricanes with devastating effects.

Measuring devices (Figure 5). For continuous measurement or recording use is made of two wind-velocity indicators, a contact anemometer built by Fuess, Berlin-Steglitz, with a contact reading after every 250 m of wind travel, and

a wind-velocity indicator built by Neufeldt & Kuhnke, Kiel, with a double cup--type anemometer, measurement by staggered styluses, direct reading, and /324 registering up to 40 m/sec.

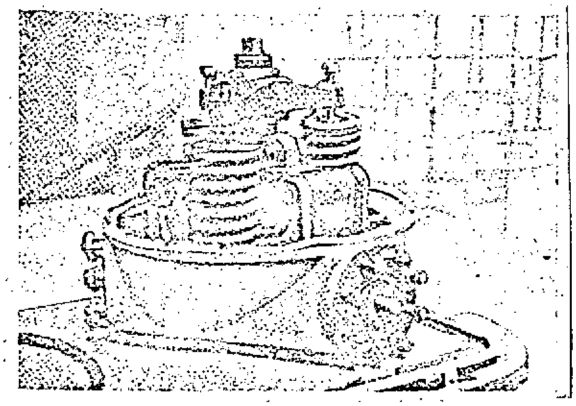

Figure 4. Aerodynamic Fan Brake (Regulating Head Open).

## Results of Operation

The windmill power generation plant reached the precalculated effective output of 18 kw (measured at the generator terminals) even on acceptance, at a wind velocity of 8 m/sec. During the first twelve months of operation (1 October 1949 to 30 September 1950) more than 30,000 kilowatt-hours were generated. The annual utilization period may at first glance appear to be short, but it must be remembered that in the small grid of the island the current generation was restricted by the relatively low power take-off and limited storage capacity, while the power supply available was considerably higher. In addition, the generating plant was not always operative, since there were initial troubles to be overcome as with all first models.

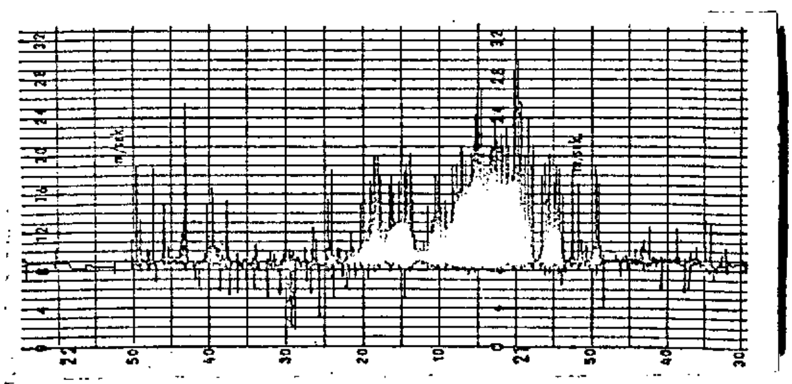

Figure 5. Recorder Chart of Wind-Velocity Indicator on Neuwerk (13 November 1950, 2,030 to 2,200 hours).

Precise data are available on use of all the power generating plants for the year 1950; they permit evaluation of the significance of the windmill

generating plant from the power production standpoint in conjunction with the other sources of energy (Figure 6). The figures given in Table 1, however, do not reveal the reasons why the individual power generating plants were shut down: scheduled maintenance, unforeseen trouble, too low or too high a wind, or deficient power take-off. These differences are shown by an excerpt from the record of operation relating to shutdown or idle time of the windmill power generating plant in 1950 (Table 2). Thus the windmill generating plant was either shut down or not used for four to 31 days during the individual months of 1950. The plant nevertheless generated 29,572 kilowatt-hours, that is, 68% of the total current generated. Thus this generating plant, with a means specific diesel oil consumption of 0.333 kg per kilowatt-hours, yielded a diesel oil saving of around 10,000 kg or 5000.00 DM.

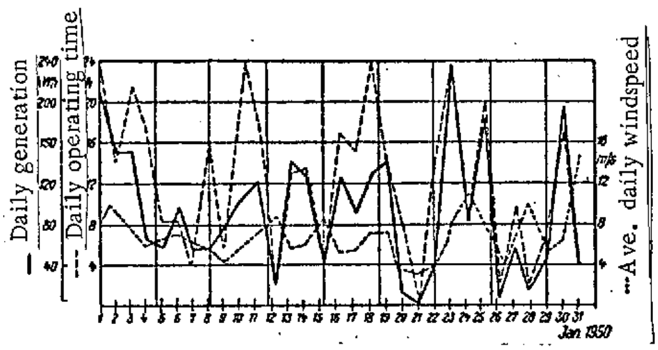


Figure 6. Total Current Generated by Wind Power in January 1950 (3,343 kwh).

In the meantime the initial difficulties and minor defects of design have been eliminated, so that an even higher percentage of generation by wind power is to be anticipated in 1951. It may be said even now that the plant has proved its value and its importance to the national economy. It has reached this goal more rapidly than many foreign designs.

In addition, the uniformity of the mean wind power output in the individual months (6.7 to 9.1 kw) indicates that this type of energy makes a valuable con- /325 tribution, at least on the North Sea coast, favored as it is by winds, to meeting both the operating requirements and the output requirements. The low generation by diesel in certain months proves that the wind power generation plant together with the battery for energy storage was able to meet the output and operating requirements set for it over lengthy periods of time.

## Prospects

We are well aware that the wind and supply conditions on the island of Neuwerk are particularly favorable for the operation of a windmill power

generation plant and that direct-current operation accompanied by storage avoids many difficulties. Utilization of wind power in larger supply grids will not have passed its final test until tests have been conducted successfully with alternating current generation. We should look forward eagerly to the results of such efforts now being undertaken on a new basis in the country and abroad.

TABLE 1. RESULTS OF POWER GENERATION OPERATION ON NEUWERK IN 1950

| Operating values | | Jan. | Febr. | Mar. | April | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual total | Monthly average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wind turbine generation .... | kWh | 3433 | 1952 | 2524 | 2636 | 2568 | 3090 | 3373 | 2356 | 2721 | 3222 | 1778 | 0 | 29572 | 2464 |
| Diesel generation I | kWh | 521 | 84 | 602 | 157 | 143 | 4 | 214 | 1245 | 331 | 57 | 1663 | 3386 | 14017 | 1168 |
| Diesel generation II | kWh | | | | | | 268 | 1221 | 2736 | 1228 | 157 | | | | |
| Total .. | kWh | 3964 | 2036 | 3126 | 2793 | 2711 | 3371 | 4808 | 6337 | 4280 | 3436 | 3441 | 3386 | 53589 | 3632 |
| Work delivered to grid ..... | kWh | 3964 | 2036 | 3126 | 2172 | 2080 | 2354 | 4102 | 5333 | 3181 | 2760 | 2519 | 2607 | 36134 | 3011 |
| Battery charge, losses ...... | kWh | ? | ? | 651 | 621 | 631 | 1017 | 706 | 1004 | 1099 | 676 | 022 | 779 | 8106 | 810 |
| Monthly total maximum load | kW | 17,8 | 9,7 | 11,3 | 8,5 | 10,6 | 17,3 | 18,2 | 31,0 | 21,0 | 12,4 | 17,6 | 16,3 | — | 16 |
| Mean wind turbine output .. | kW | 7,7 | 7,4 | 8,3 | 7,8 | 6,7 | 7,0 | 7,2 | 6,8 | 9,1 | 7,7 | 7,6 | 0 | — | 7,6 |
| Maximum wind turbine output | kW | | | | | | | | | | | | | | 23,3 |
| Total monthly hours | h | 744 | 672 | 744 | 720 | 744 | 720 | 744 | 744 | 720 | 744 | 720 | 744 | 8760 | 730 |
| Running time, wind turbine | h | 386 | 244½ | 303 | 338¾ | 385½ | 441¼ | 463¾ | 347½ | 297½ | 416 | 215 | — | 3838,75 | 348,97 |
| Running time, diesel I | h | 28¼ | 3½ | 21¾ | 6 | 13¾ | ½ | 18½ | 118¾ | 29¾ | 5½ | 25 | 160 | 784,74 | 65,39 |
| Running time, diesel II | h | | | | | | 10¼ | 56½ | 116,0 | 43¾ | 5 | 52 | 70 | | |
| Diesel oil consumption, total I | kg | 198¾ | 30 | 100¾ | 51¼ | 53 | 1¾ | 80½ | 462 | 110¾ | 18¾ | 88¾ | 441 | 4664,80 | 388,73 |
| Diesel oil consumption, total II | kg | | | | | | 84¾ | 400 | 881¼ | 377¾ | 48¾ | 584 | 561 | | |
| Diesel oil consumption per kWh generated I | kg/kWh | 0,381 | 0,357 | 0,316 | 0,326 | 0,370 | 0,337 | 0,376 | 0,371 | 0,335 | 0,329 | 0,355 | 0,356 | — | 0,350 |
| Diesel oil consumption per kWh generated II | kg/kWh | | | | | | 0,316 | 0,327 | 0,322 | 0,308 | 0,310 | 0,312 | 0,321 | — | 0,316 |
| Mean wind velocity .... | m/s | 7,2 | 8,6 | 7,4 | 7,0 | 6,3 | 6,3 | 6,5 | 5,6 | 7,0 | 8,6 | 8,1 | 7,7 | — | 7,2 |
| Max. wind velocity .... | m/s | 19,2 | 17,6 | 19,6 | 20,4 | 13,7 | 17,0 | 17,1 | 17,8 | 20,4 | 17,0 | 37,0 | 40,0 | — | 21,4 |
| Min. wind velocity . | m/s | 0 | 0 | 1,0 | 0 | 0 | 1,1 | 0 | 0 | 1,2 | 0 | 0 | 0 | — | 0 |

TABLE 2. SHUTDOWN AND IDLE TIMES OF WINDMILL POWER GENERATION PLANT

| Month | Days with no Generation by Wind Power | Cause |
|---|---|---|
| January | 2 | Wind too strong |
| | 3 | No wind |
| February | 3 | Battery full |
| | 5 | Wind too strong |
| | 1 | No wind |
| March | 2 | Gearing at foot replaced |
| | 2 | Wind too strong |
| | 3 | No wind |
| | 2 | Battery full |
| April | 3 | Wind too strong |
| | 1 | Battery full |
| May | 1 | Wind too strong |
| | 5 | No wind |
| | 1 | Battery full |
| June | 1 | Battery full |
| | 1 | Wind too strong |
| | 3 | No wind |
| July | 3 | Wind too strong |
| | 4 | Wind too low |
| | 1 | Turbine being repaired |
| August | 5 | Turbine being repaired (regulating head) |
| | 2 | Wind too strong |
| | 4 | No wind |
| September | 7 | Clutch being replaced |
| | 5 | Wind too strong |
| | 1 | No wind |
| October | 9 | Battery full |
| | 3 | Wind too strong |
| | 2 | No wind |
| November | 2 | Battery full |
| | 1 | No wind |
| Shut down on 23 November 1950 | 7 | |
| December | 31 | Bearings damaged |
| | | Bearings damaged |

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