An operational windmill in an open-air museum as a conservation challenge: Lessons from projects recently implemented in Poland

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An operational windmill in an open-air museum as a conservation challenge: Lessons from projects recently implemented in Poland
The article discusses the methods of protecting historic windmills and recognising them as valuable objects of industrial heritage. Therefore, examples of attempts to restore windmills as working mills after 2010 are discussed. Translocation combined with comprehensive renovation can be an effective and desirable method of conservation for historic windmills with a wooden structure, as it enables the restitution of these facilities as operating mills. However, one should be aware of the risks associated with this type of activity: primarily the risk of losing the historic, original substance of the mill and changing its landscape context. An important problem is the safety of the dynamic exhibition and the lack of professionals – millers specialised in the field of drive mills, who would be able to not only set up the technological process but also maintain the machines included in it on an ongoing basis. The following part of the article discusses 12 examples of attempts to restart historic windmills. These examples are divided into two categories of objects: windmills with an alternative, modern electric drive; windmills with the ability to work using only wind power. The analysed examples of windmill conservation and reactivation provide the basis for formulating lessons for future projects in Poland and abroad.

Keywords: windmill, milling technology, reactivation, industrial heritage conservation

Introduction

This article focuses on the issue of protection and maintenance of windmills, with particular emphasis on translocation to open-air museums and restoration to a technical condition enabling operation. The main motivation to take up the topic was that windmills were underestimated as technical monuments of rural industry. The architecture, structure and equipment of a windmill form a compact and logical whole, and the preservation of all these elements determines the integrity of the monument. For this purpose, the article discusses

and analyses the conservation activities of historic windmills in Poland undertaken by open-air museums and local governments. Due to the extensiveness of the subject, the focus is on recent (after the year 2010) implementations that have taken place in the current socio-economic reality and are therefore the most useful from the point of view of lessons for the future, which are formulated in the summary of this work.

Historical background

Industrial heritage objects were identified as monuments relatively late, occurring only in the 1950s and 1960s.[1] Nevertheless, rural architecture had become an object of scientific interest much earlier, in the 1870s.[2] The first initiatives to protect windmills in Europe were taken in 1923 by the association of Dutch mills De Hollandsche Molen.[3] In 1926, the association purchased the Adriaan windmill in Haarlem. It is worth mentioning here that at the end of the 1920s, the problem of preserving windmills was noticed by Bernhard Schmid, a Prussian conservator of monuments operating in the province of West Prussia. Due to the greater efficiency of industrial mills, windmills (of which there were 62 in that province) gradually ceased to fulfil their function. However, their importance to the landscape and historical value were noticed – in Żuławy they had been present since the Middle Ages.[4] In 1927, the Senate of the Free City of Gdańsk protected the three most important drainage mills in Orłowo (Orloff), Orłowskie Pole (Orloffenfelde) and Ostaszewo (Schöneberg).[5] In Poland, the post-war inventory of windmills of historic value was made at the end of the 1950s. The records covered 867 windmills, the largest clusters of which were recorded in the then Poznań and Warsaw voivodeships.[6] The first entries in the register of monuments come from this period, granting "recognition as a monument."[7] The first post-war windmill conservation initiatives were primarily related to the development of open-air museums. The oldest open-air museum in Poland is the Museum – Kashubian Ethnographic Park, established in Wdzydze Kiszewskie in 1906. At a similar time, the Museum of Folk Architecture – Ethnographic Park in Olsztynek was founded, the beginnings of which date back to 1909. It was then that a decision was made in Królewiec to create a museum of rural architecture. About 20 copies of objects from the eighteenth and nineteenth centuries were erected in the Królewiec Zoo, including a copy of a windmill (paltrok mill) from Schönfließ (now Komsomolskoje in the Kaliningrad region). In the years 1938–1942, the open-air museum was moved to Olsztynek. The Schönfließ windmill was

[1] WALCZAK, Bartosz M. Czy zabytki techniki i inżynierii to w Polsce wciąż dziedzictwo "drugiej kategorii"? Rys historyczny oraz aktualne problemy, [Are monuments of technology and engineering in Poland still a "second-class" heritage? Historical outline and current problems]. In: *Ochrona Dziedzictwa Kulturowego*, 2 (16), 2016, pp. 133–144 [in Polish].

[2] CZAJKOWSKI, Jerzy. Muzea na wolnym powietrzu w Europie [Open-air museums in Europe]. Rzeszów – Sanok: KAW, 1984, p. 6 [in Polish].

[3] PRARAT, Maciej, Architektura wiejska w granicach Prus Zachodnich jako przedmiot zainteresowań naukowych i konserwatorskich do lat 40. XX w. [Rural architecture in West Prussia as a matter of interest of Conservation and Monument Studies until the 1940s]. In: *Acta Universitatis Nicolai Copernici: Zabytkoznawstwo i Konserwatorstwo*, vol. XLV, 2014, pp. 185–221 [in Polish].

[4] Ibidem.

[5] Relics of the drainage windmill from Ostaszew are kept in the Żuławy Museum in Nowy Dwór Gdański.

[6] GDANIEC, Zygfryd. Dzień dzisiejszy wiatraków [Windmills today]. In: *Mówią Wieki*, 11, 1968 [in Polish].

[7] An example is the decision of the Department of Culture of the Presidium of the Provincial National Council in Łódź, No. Kl.III-52/14/57 of December 16, 1957, recognising the windmill – post mill in Solca Wielka (Ozorków commune) as a monument, and the decision No. Kl. III-52/11/60 of March 26, 1960, recognising the windmill – post mill in Dąbrowa (Zelów commune) as a monument.

restored in 2015–2016.[8] One of the oldest open-air museums in Poland is Skansen Kurpiowski in Nowogród. Its creation was first suggested in 1919, and the institution was opened in 1927. After World War II, the idea of an open-air museum in Poland began to develop dynamically. Museums were established in Zubrzyca Górna (1957), Sanok (1958), Toruń (1959), Opole (1960), and Chorzów (1961).[9] The first translocations of windmills for exhibition purposes took place in the 1960s. The windmill from Plewki can be mentioned here, which moved in the early 1960s to the open-air museum in Nowogród.[10] Other examples include the paltrok mill from Grzawa, translocated to Chorzów (1964, fig. 2–6), and the tower mill from Dobrocin (1962–1965, fig. 27), transferred to Olsztynek. In subsequent decades, there were further open-air museum initiatives, under which the care of windmills was taken over by museologists. By 1979, 26 windmills had been translocated to Polish open-air museums.[11] In 2022, according to the authors' research, the number of windmills in museum collections was 77. Of these, we can distinguish 48 post mills, 13 tower mills, 13 paltrok mills and 3 turbine windmills.

Recently, that is, after 2010, a tendency to restore windmills as working mills has become noticeable. Most of these initiatives are undertaken by museum institutions. Attempts to restart the windmills have met with various problems concerning conservation and organisation. It is worth taking a closer look at these initiatives, analysing them and drawing relevant conclusions.

The article is of a synthetic nature – it consists of an analysis of previous experiences of translocations and attempts to restore windmills as working mills undertaken by Polish open-air museums (*ex post* research). As a result of the research, conclusions of a more general nature have been formulated – a proposal of conservation principles for the reoperation of windmill mechanisms.

Translocations and attempts to restore windmills as working mills

The very poor technical condition of many historic windmills that have survived to this day means that they often require major repairs, including the replacement of a significant number of structural elements. A comprehensive mill restoration often involves relocation, usually to an open-air museum. Such renovation requires dismantling and dismembering the entire structure of the monument, making the necessary repairs and patchwork, replacing the most degraded elements and then reassembling the translocated object into one logical whole. Unfortunately, in many cases, the scope of interference in the historic, authentic substance of the windmill is so large that the object loses the value of antiquity. The patina, which is a natural effect of the passage of time, gives way to new elements, and the way in which it is made (mainly in terms of wood processing) and appearance differ from the original. The relocation means changing the landscape context around the mill. Sometimes such a change can have a positive effect on the exposure of the windmill in the landscape. More often, unfortunately, it is the other way around. At this point it is worth recalling the example of the Dutch approach

[8] CHODKOWSKA, Wiesława, SABLJAK-OLĘDZKA Monika. *O wiatrakach Warmii i Mazur i młynarzu z daleka…* [About the windmills of Warmia and Mazury and the miller from afar…]. Olsztynek: Muzeum Budownictwa Ludowego – Park Etnograficzny w Olsztynku, 2016, s. 133 [in Polish].

[9] CZAJKOWSKI, Muzea…, p. 220.

[10] ŚWIĘCH, Jan. Młyny wietrzne i wodne w muzeach na wolnym powietrzu w Polsce. Problemy translokacji, rekonstrukcji, demonstracji i konserwacji [Wind and water mills in open-air museums in Poland. Problems of translocation, reconstruction, demonstration and conservation]. In: *Problemy ochrony młynów jako zabytków techniki i architektury*. Radom: Muzeum Wsi Radomskiej, 2021, p. 10 [in Polish].

[11] Ibidem, p. 11.

to mill conservation, as formulated in the study "A future for mills: Principles for dealing with heritage mills". There is a very strong emphasis on the integrity of the monument, which concerns not only the mill itself but also its landscape and social context. Relocation is therefore not recommended in the Netherlands.[12] However, one should be aware that in Polish socio-cultural conditions, where there is a lack of sensitivity to the generally understood quality of space and protection of the cultural environment, relocating windmills is often the only way to preserve them for future generations. In addition, translocation combined with comprehensive renovation can be an effective and desirable method of conservation for historical windmills with a wooden structure, as it enables the restitution of these objects as working mills. In the case of monuments of technology, an important conservation postulate is to activate them at least periodically, which positively affects the technical condition of the mechanisms. According to Święch, already in 1934, Maria Znamierowska-Prüfferowa argued that windmill mechanisms should be complete and ready for demonstration work and that museums should be places for cultivating old techniques and specialist knowledge passed on to the next generations of craftsmen.[13]

Recently, several such attempts have been made in Poland. These initiatives (apart from the in situ commissioning of the tower mill in Pyzdry and the roller windmill in Kałkowskie in Greater Poland) were related to the relocation. Sometimes, the restoration of technical efficiency concerned only certain movable elements (e.g., the possibility of turning the windmill buck on the main post).

Similar developments are also taking place in other Central European countries and regions (e.g., Transylvania).[14] Comparable functional and spatial solutions for windmills can also be observed along the Baltic Sea basin (Fig. 1).[15] Moreover, the socio-economic context of political transformation is similar for all countries of the former socialist bloc. Thus, the Polish experience may be useful for analogous initiatives in this region.

Fig. 1: *A post windmill in the Estonian Open-Air Museum*; photo by B. M. Walczak, 2020.

Starting mechanisms that have been frozen for years are usually problematic. Most of the windmills that work at least occasionally suffer from "man conservation," that is, technical and organisational problems. In almost every case, conservators and museum curators face a choice: on the one hand, they want to preserve the original substance of the monument; on the other hand, they want to "revive" it as an efficient mechanism. In addition, there are issues related to the safety of the dynamic exhibition, as well as the problem of choosing the location of the windmill (in the event of its relocation) to ensure appropriate

[12] Bazelmans, Jos, van Hof, Jan, Nienhuis, Geert, Troost, Gerard, and Pfeiffer, Wouter (2012). A Future for Mills: Principles for dealing with heritage mills, Amsterdam: RCE Cultural Heritage Agency 2012.

[13] ŚWIĘCH, Jan. Ochrona młynarstwa wiejskiego w polskich muzeach na wolnym powietrzu [Protecting rural milling in Polish open-air museums. Assumptions and implementation]. In: A. Przybyła-Dunin, B. Grabny, P. Roszak-Kwiatek (eds). *Młynarstwo tradycyjne – wczoraj, dziś, jutro… Problemy zachowania ginącego dziedzictwa*. Chorzów 2017, p. 141 [in Polish].

[14] BITAY, Enikő, MÁRTON, László, TALPAS, János, The story of a re-operating windmill, In: *Műszaki Tudományos Közlemények*, vol. 14, 2021, pp. 10–17.

[15] HORN, Kirsti (ed.), *Windmills in Estonia, Finland and Sweden*, Enja Publishing, Vantaa 2015.

wind conditions and preserve the landscape values of the monument.

The profession of a miller required special predispositions: physical fitness, endurance, good hearing, and general technical skills.[16] A journeyman candidate had to be able to recognise the quality of the grain, know how to clean it, operate mill mechanisms, make repairs and sharpen millstones.[17] Today, due to the interruption of the generational continuity of the profession and very large changes in milling technology (including changes in the method of drive transmission and transport of products within the mill), the profession of a miller in its traditional meaning is a disappearing profession. A windmill seems to be a fairly simple mechanism, but anyone who wants to keep such an object in motion must admit that it is not easy at all. A working windmill is a "living organism" – wooden gears work, dry out or swell, looseness appears here and there, transmission belts fall off the wheels, gear teeth wear out and bearing shells require regular lubrication. Millstone set-ups are also unreliable: it is sometimes difficult to maintain an equal distance between their working planes. All this means that today (as in the past) the windmill requires constant care, which is associated with costs and organisational effort. Nowadays, a very important issue is who performs the translocation and renovation of the windmill and how it is undertaken. While carpentry work is not a major problem, the maintenance and adjustment of internal mechanisms are. It needs to be clearly articulated: working internal mechanisms require specialist knowledge and experience. Therefore, without cooperating with specialists (milling technologists), carpenters will not be able to cope with the complex and multithreaded task of commissioning a historic windmill.

Case studies of commissioning historic windmills in Poland

The selected examples of restoring windmills as working mills presented in the following part of the article are based primarily on the authors' own experiences and on the accounts of museum employees. Taking into account the number of windmills in open-air museums in Poland alone, the selected examples probably do not exhaust the issues that require further research. The group of windmills that have been restored to full or partial technical efficiency (or for which at least such an attempt has been made) includes:

- a windmill – paltrok (rebuilt from a post mill) from Grzawa in the Upper-Silesian Ethnographic Park Museum in Chorzów;
- a windmill – post mill from Wierzbica in the Radom Village Museum in Radom;
- a windmill – post mill from Zalesie in the Mazovian Countryside Museum in Sierpc;
- a windmill – post mill from Markowa in the Croft Museum of Markowa Village;
- a windmill – post mill from Zawada in the open-air museum Łęczyca Croft in Kwiatkówek near Łęczyca;
- a windmill – post mill from Dębno in the Kielce Village Museum in Tokarnia;
- a windmill – post mill from Zaduszniki in the Kujawsko-Dobrzyński Ethnographic Park in Kłóbka;
- a windmill – post mill from Wojtówka in the Maria Znamierowska-Prüfferowa Ethnographic Museum in Toruń;
- a windmill – post mill from Wodziany in the Museum of Folk Architecture –

[16] ŚWIĘCH, Jan. Wiatraki. *Młynarstwo wietrzne na Kujawach* [Windmills. Wind milling in Kujawy], Włocławek 2001, p. 140 [in Polish].

[17] WESOŁOWSKA, Henryka. *Młynarstwo wiejskie Opolszczyzny od XVIII do XX wieku* [Rural milling of the Opole region from the eighteenth to the twentieth centuries], Opole: Instytut Śląski w Opolu, 1969, s. 168 [in Polish].

Ethnographic Park in Olsztynek;

- a windmill – paltrok from Ruska Wieś in the Museum of Folk Architecture – Ethnographic Park in Olsztynek;
- a windmill – smock mill from Dobrocin in the Museum of Folk Architecture – Ethnographic Park in Olsztynek;
- a windmill – post mill from Czacz in the Museum of Milling and Water Equipment of Rural Industry in Jaracz.

Windmills from the above list will be discussed later in the article. All the above-mentioned objects have been translocated. There are, however, other windmills worth mentioning: the wooden tower mill from Brusy in the Kashubian Ethnographic Park in Wdzydze Kiszewskie (which has technological equipment so well preserved that it could be put back into operation without any major problems), the windmill – post mill from Niemyje Nowe in the Agricultural Museum in Ciechanowiec and a fully functional windmill – post mill from Wroniawa in the Museum of Folk Architecture of Western Greater Poland in Wolsztyn.[18] It is also worth mentioning here other technically efficient windmills not in museum exhibitions:

- a windmill – paltrok in Kałkowskie, the community of Sośnie in the Greater Poland Voivodeship, which was restored in situ and brought back to a usable condition in 2004;
- a windmill – paltrok in Mokry Dwór, the community of Pruszcz Gdański in the Pomeranian Voivodeship, which was translocated from Wyszogród in 2016–2019;
- a windmill – post mill in the Millers Croft in Uniejów in the Łódź Voivodeship, which was translocated from Zbylczyce in 2000–2012;
- a smock mill in the Olandia holiday and conference centre in Prusim, the community of Kwilcz in the Greater Poland Voivodeship, which was translocated from Niegocin in 2012;
- a windmill – post mill in the Olandia holiday and conference centre in Prusim, the community of Kwilcz in the Greater Poland Voivodeship, which was translocated from Krzywosądów in 2022;
- a windmill – post mill in Leszno in the Greater Poland Voivodeship, which was translocated in 2018 within the city (it now stands at the intersection of Osiecka and ks. J. Popieluszko streets);
- a tower mill in Pyzdry in the Greater Poland Voivodeship was restored in situ in 2019.

Windmills with an alternative, modern electric drive

A windmill from Grzawa in the Upper-Silesian Ethnographic Park Museum in Chorzów

An excellent example of a working windmill is the object translocated in 1964 from Grzawa, currently exhibited in the Upper-Silesian Ethnographic Park Museum (Fig. 2–6). The mill was renovated and relaunched in 2014. It is a paltrok rebuilt from a post mill. It is an atypical windmill and is the only object of this type exhibited in an open-air museum in Poland. The mill dates back to the first half of the nineteenth century. The mill was in operation until

[18] It is the second oldest windmill in Poland. The date 1603 is preserved on the crown tree, the date 1733 on the main post trestle brace, the date 1744 on the head wheel. This mill was translocated to the museum in the late 1990s.

around 1918.[19] Due to the topography of the area, the windmill currently has limited ability to work with the help of wind power. The equipment of the windmill includes: a windshaft with a head wheel, a quant with a stone nut cooperating with the wheel; a brake system; a millstones set-up; a crane for lifting millstones, a beam for runner-stone level regulation and a flour bin with sleeve bolter for flour dressing. The flour bin and the sleeve bolter are not original – they were reconstructed according to the design from 1964.[20] Inside the building, there is an electric motor (4 kW) with a gear motor driving the windshaft and technological devices (millstones set-up and sleeve bolter mechanism). The motor was placed by the rear (tail) wall of the windmill above the windshaft (Fig. 5, 6). The gear motor is connected through a double chain with the windshaft stub (from the rear, leeward side). A toothed wheel connected by a chain to the wheel on the output shaft of the gear motor was mounted on the shaft stub. The installation of the engine was preceded by the preparation of design documentation and calculations. The calculations showed that the effective power of the windmill sails (the power transferred by the wind motor to the power receiver) is only 1.98 kW at a torque of 11.93 Nm. On this basis, the power of the electric motor was assumed.

The solution used in the windmill from Grzawa is simple and almost failure free. However, the electric motor power turned out to be insufficient – with the help of the engine, the windshaft rotated very slowly, at a rate of two revolutions per minute, but only if the millstones set-up worked without crushing the grain.[21] However, in good weather – that is, sufficiently strong wind – the windmill could work without the support of an electric motor and effectively grind grain.[22] Currently (2023) windmill operation demonstrations have been temporarily suspended due to the following problems:

- deflection of one pair of sails at the point of attachment in the windshaft canister; there is a risk of breaking the sails due to the small cross-section of stocks – load-bearing beams embedded in the windshaft canister (it is necessary to replace and strengthen the stocks with steel elements);
- improper centring of the windshaft;
- wearing off of the windshaft wooden bearing in the breast wall; the shaft is not fixed at the right angle (approx. three degrees) – it is arranged almost horizontally, which causes the risk of the sails catching on the breast wall (it is necessary to use a stone bearing and properly seat the shaft head on it);
- delamination of the upper part of the post slab (on which the body of the mill rotates), caused by the uneven distribution of loads between the crowntree and the ceiling of the

[19] *Protokół z ostatecznego zakwalifikowania zabytkowego obiektu: obiekt: wiatrak /młyn wietrzny/, wieś Grzawa, powiat Pszczyna* [Protocol on the final qualification of the historic object], May 11, 1962; CIECHANOWICZ, K., WOŁYNIAK, J. *Opis obiektu zakwalifikowanego do skansenu* śląskiego [Description of the object qualified to the Silesian open-air museum], Gliwice August 28, 1962. Source: archive of the Upper Silesian Ethnographic Park, inventory number 547 [in Polish].

[20] RZECHUŁA, Z., SZUNKE, S., MOSZUMAŃSKI, B. *Projekt rekonstrukcji wiatraka z m. Grzawa* [Reconstruction project of the windmill from Grzawa], Kraków: Przedsiębiorstwo Państwowe Pracownie Konserwacji Zabytków, 1964. Source: archive of the Upper Silesian Ethnographic Park, inventory number 566 [in Polish].

[21] ROSZAK-KWIATEK, Paweł. Opinia etnograficzna i doradztwo techniczne w zakresie weryfikacji dokumentacji projektowo-kosztorysowej wiatraka z Zalesia ze zbiorów Muzeum Wsi Mazowieckiej w Sierpcu [Ethnographic opinion and technical advice on the verification of the design and cost documentation of the windmill from Zalesie from the collection of the Museum of the Mazovian Village in Sierpc], Bytom 2019, pp. 5–6 [in Polish].

[22] According to Paweł Roszak-Kwiatek, an employee of the Museum specialising in rural industry.

first floor equipped with trolleys (it is necessary to relieve the crowntree by using pads under the "rail" on which the trolleys roll);

- incorrect execution of the so-called brake lift, making it difficult to lift the brake lever, the so-called press (proper execution of the lift is required).

Fig. 2: *The windmill from Grzawa in the Upper-Silesian Ethnographic Park Museum*; photo by F. Tomaszewski, August 2022.

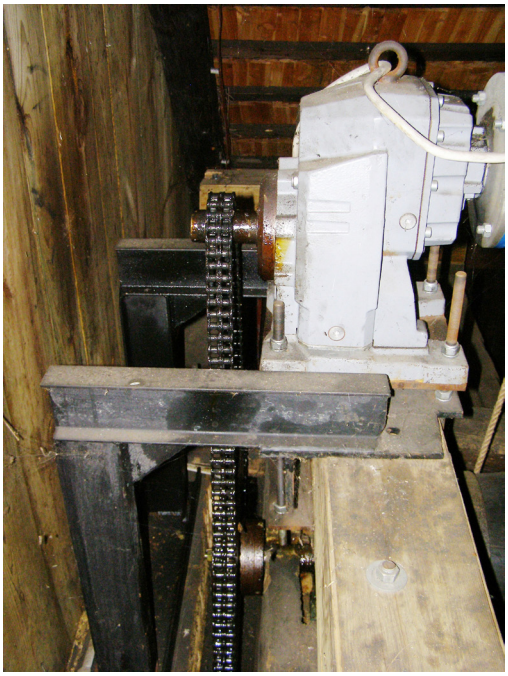
Fig. 3: *The exhibition inside the windmill from Grzawa in the Upper-Silesian Ethnographic Park Museum*; photo by P. Roszak-Kwiatek, August 2016.

Fig. 4: *Windmill from Grzawa at work; source: Upper-Silesian Ethnographic Park Museum.*

A windmill from Wierzbica in the Radom Village Museum in Radom

In November 2017 to June 2018, the post mill was translocated within the Radom Village Museum in Radom (Fig. 7–11). This windmill, dating back to 1896, was moved to the museum from Wierzbica in 1986. For many years, it served as a museum café.[23] The windmill in its previous location in the open-air museum was oriented with its sails towards the east, and its exposure from the north was interrupted by single-family houses. As it was impossible to set the sails in the direction of the wind, the object was therefore moved south for a distance of approximately 400 m to the croft sector.

[23] *Zakończono prace przy Wiatraku z Wierzbicy* [Works on the Windmill from Wierzbica have been completed], accessed October 5, 2018, http://www.muzeum-radom.pl/muzeum-wsi-radomskiej/efrr/zakonczono-prace-przy-wiatraku-z-wierzbicy/2282 [in Polish].



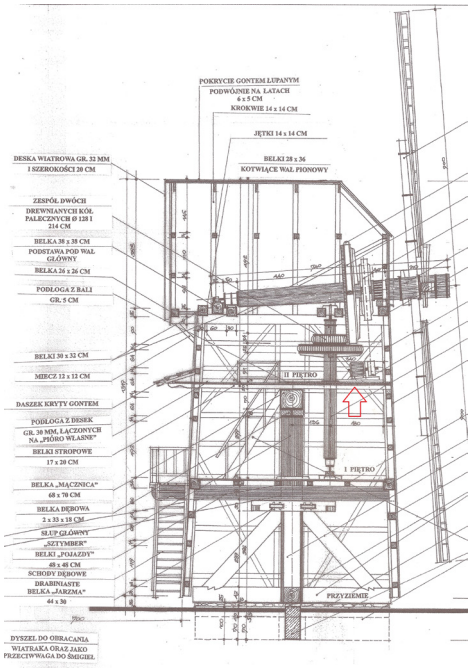


Fig. 5–6: *An electric motor with a gear motor in a windmill from Grzawa*; photo by F. Tomaszewski, August 2022.

The purpose of the renovation and relocation was to enable the demonstration work of the mill. The windmill has a very unusual drive transmission system from the head wheel, similar to those used in tower mills: the head wheel works with an upright shaft[24] that passes through the second and third storeys, located between the crowntree and the breast wall (on the windward side, where the sails are located). This shaft drives two millstone set-ups via wooden gears (Fig. 9), one of which serves as a grinding mill, while the other is used for the production of flour, cooperating with the sleeve bolter. Inside there is also a winnower for grain cleaning and a husk for groats production. For utility reasons, it was decided to install an electric motor as the alternative drive in the mill. This 3 kW motor (equipped with a gearmotor) transmits the drive directly to the wheel mounted on the windshaft via a belt (Fig. 11). In the case of the mill from Wierzbica, the engine is not hidden but rests on the floor.

During the start-up of the mill, there were several problems with the implementation of the ambitious goals: the possibility of turning the building with the sails to the direction of the wind was abandoned due to a problem with the centring of the windshaft and the tension of the belt connecting the shaft with the electric motor, and because the gear wheels cooperating with the head wheel were not connected (the gear was decoupled). After making the appropriate corrections (including centring the shaft), the museum conducted several shows that proved very popular with visitors. However, the problem remains that after 20 minutes the drive belt heats up and rotation becomes more difficult. Therefore, the presentation cannot last too long. But after a break of about 20 to 30 minutes, the belt is ready for the next show. Several times a year the belt must be lubricated with a special adhesive for drive belts.[25]

[24] The Radom Village Museum has in its collection three windmills – post mills with upright shafts. These are windmills from Dąbrowa Jastrzębska, Grabowiec and Wierzbica.

[25] According to Andrzej Żytnicki, an employee of the Radom Village Museum.

Fig. 7: *Cross-section through the building of the windmill from Wierzbica in the Radom Village Museum, the red arrow marks the location of the electric motor*; source: tender materials for windmill relocation and renovation (drawing by technician Jerzy Biedron).

Fig. 8: *A general view of the windmill in Wierzbica*; photo by F. Tomaszewski, December 2019.

Fig. 9: *The upright shaft at the windmill from Wierzbica*; photo by F. Tomaszewski, December 2019.

Fig. 10, 11: *The windmill from Wierzbica at the Radom Village Museum; the electric motor with the gear motor transmitting the drive directly to the pulley mounted on the windshaft*; photo by F. Tomaszewski, December 2019.

A windmill from Zalesie in the Mazovian Countryside Museum in Sierpc

In 2020, a major renovation was carried out on the post mill in the Mazovian Countryside Museum in Sierpc (Fig. 12–14). This windmill, dating back to around 1860, was relocated to the Museum from Zalesie in 1987.

Fig. 12: *A windmill from Zalesie in the Mazovian Countryside Museum in Sierpc during restoration works*; photo by J. Jankowski, May 2020.

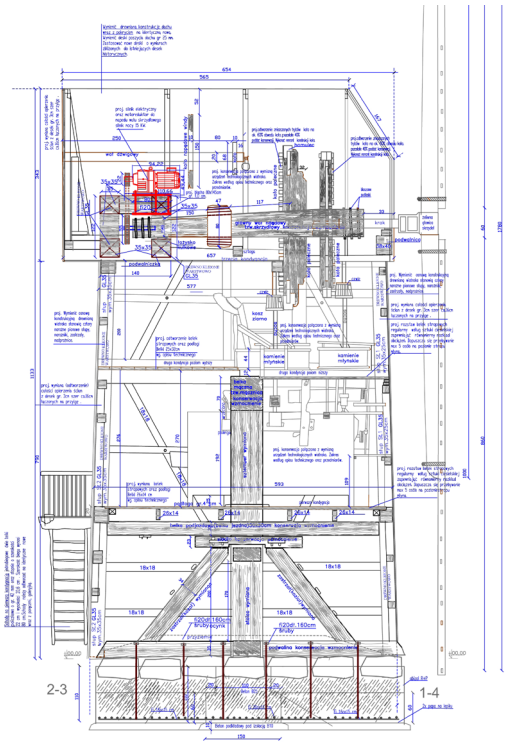


Fig. 13: *A windmill from Zalesie after renovation*; source: https://mwmskansen.pl [accessed: August 24, 2022].

The purpose of the renovation was to enable the demonstration work of the mill. The windmill is equipped with two finger wheels driving two assemblies of millstones. On the first floor, there is a square sifter. The windmill is equipped with a 15 kW electric motor, which enables the mill to be run for demonstration. The location of the engine and the method of transmission of the drive is similar to the windmill from Grzawa (the engine mounted above the windshaft in the area of the tail wall transmits the drive via a chain to the toothed wheel on the shaft stub).

Fig. 14: *Cross-section through the building of the windmill from Zalesie in the Mazovian Countryside Museum in Sierpc; the location of the electric motor is marked in red; source: construction design for the renovation and modernisation of the post windmill – stage I, documentation update made in 2015*; author: Zbigniew Chomiczewski, September 2019.

During the renovation, the building was completely dismantled and then reassembled. A many of the construction elements were replaced, including the crowntree (Fig. 12).

The first attempts to start the windmill with an electric motor caused failures in the chain transmission. However, the shortcomings were remedied and the windmill is now operational.

A windmill from Markowa in the Croft Museum of Markowa Village

Finally, one more mill should be noted in which an electric motor was installed to demonstrate the activation of at least the sails. It is a small windmill from Markowa, exhibited in the Croft Museum of Markowa Village, an open-air museum run by the Society of Friends of Markowa (Fig. 15). The windmill from Markowa represents a type of small peasant farmstead windmill and is equipped with a pair of millstones.

Fig. 15: *Windmill in the Croft Museum of Markowa Village*; source: https://skansen-markowa.pl/index.php/zbiory-i-ekspozycje/wiatrak-kozlak.html [accessed: August 24, 2022].

Observations

Installing motors in mills exhibited in open-air museums may raise doubts about the authenticity of the technical solutions, but it significantly facilitates the organisation of windmill operation demonstrations. The introduced new mechanisms, however, can be unreliable and are another element that requires care and regular service. From the examples described above, the chain drives used in the windmills from Grzawa and Zalesie should be distinguished as the least problematic and as interfering least with the original character of the mills. In the case of

the windmill from Grzawa, the engine power (3–4 kW) turned out to be insufficient. Previous experience shows that the optimum power of the drive source should be around 10 to 15 kW.[26]

Windmills driven solely by the power of the wind

If, despite the translocation, the windmill has not lost the ability to use wind power (it has been located in an open area), it may be possible to run it. However, it should be borne in mind that the act of reefing the sails (i.e., spreading the sailcloth or wooden shakes) is cumbersome and time-consuming – but it is this way of setting the sails in motion that best reflects the historical truth. For organisational reasons, such windmill demonstration work takes place only occasionally (e.g., to coincide with other events). Below are examples of windmills whose technical condition allows setting the sails to the direction of the wind and their occasional start-up.

A windmill from Zawada in the Łęczyca *Croft open-air museum in Kwiatkówek*

In 2011, the Museum of Archeology and Ethnography in *Łódź* translocated a post mill from Zawada to the Łęczyca Croft open-air museum in Kwiatkówek near *Łęczyca* (Fig. 16–20). The building dates back to around 1820. It was brought to Zawada around 1900 from Kwiatkówek near *Łęczyca*.[27] Thus, this is an unusual case of a windmill returning (after 112 years) to its original location (of course, the object is not in the exact same place, but the margin for error is certainly not too large). The windmill stopped working in 1957. From that date until September 2011, the building survived almost unchanged. Before the translocation, the windmill represented the peak stage of the development of post-mill equipment. It should be emphasised that despite numerous modernisations, the building has retained its original character, that is, the driving force of the mill machines has always been the wind.

An architectural and conservation inventory was prepared and mycological expertise sought for the mill.[28] During the relocation, it was decided to return to the original nineteenth-century technological layout. As a result of the translocation and renovation, the structure of the building was largely reconstructed (the original structure was in a critical technical condition), while the preserved equipment remained original. However, the twentieth-century layers in the equipment were removed, which is why, for example, the mill rollers were not put in their previous location inside the mill, but are on show outside (Fig. 20). For utility reasons, it was decided to replace the windshaft only. A windshaft with a cast-iron head, from another demolished windmill, was used as a replacement. The original shaft with a wooden head is displayed near the object. Currently, it is possible to adjust the windmill's sails to the direction of the wind. The sails and the shaft and technological devices are not activated regularly, but their technical condition allows activation at any time (depending also on wind conditions). At least twice a year, at the end and beginning of the tourist season, the sails are rotated 180

[26] This is confirmed by historical examples of modernisation of windmills, e.g., an 11 kW motor was installed in the windmill in Pyzdry, and the windmill in Leszno (with a modernised process line with lower power demand) had a 7.4 kW motor fitted.

[27] POSŁUSZNA, Ewa, *Karta ewidencyjna zabytku architektury i budownictwa – wiatrak w Zawadzie* [Record card of a built heritage object – a windmill in Zawada, 1983 [in Polish].

[28] WŁODARSKA, Danuta, ZAJĄC, Marcin, PRZYBYŁOWSKI, Wojciech, TOMASZEWSKI, Filip. *Projekt budowlany zespołu muzealnego w Tumie "Tum – perła romańskiego szlaku" – rozbiórka, odbudowa i translokacja wiatraka typu kozłowego w Zawadzie, dz. nr 68/2, 68/4, obręb Kwiatkówek* [Construction project of the museum complex in Tum "Tum – the pearl of the Romanesque trail" – demolition, reconstruction and translocation of a trestle-type windmill in Zawada, plots no. 68/2, 68/4, Kwiatkówek precinct], Łódź 2010–2011 [in Polish].

degrees,[29] which is extremely important from the conservation point of view, as it prevents their gravitational deflection.

Fig. 16: *A windmill from Zawada before its translocation*; photo by F. Tomaszewski, 1999.

Fig. 17: *A windmill from Zawada during disassembly*; photo by F. Tomaszewski, September 2011.

Fig. 18: *A windmill from Zawada during reconstruction at the Łęczyca Croft in Kwiatkówek; the timber-frame structure was entirely recreated from new material*; photo by F. Tomaszewski, November 2011.

Fig. 19: *A roller mill inside the windmill from Zawada (before translocation)*; photo by F. Tomaszewski, 1999.

[29] According to Wojciech Bernasiak, a coordinator of the Łęczyca Croft in Kwiatkówek.

Fig. 20: *The same roller mill as an element of an outdoor exhibition in Łęczyca Croft*; photo: F. Tomaszewski, July 2018.

A windmill – post mill from Dębno in the Kielce Village Museum in Tokarnia

The post mill from Dębno in the museum in Tokarnia (Fig. 21) dates back to 1880.[30] The object was launched in 2010. At present, it is possible to set the sails to the direction of the wind, and the sails have the ability to rotate and move millstones. The location of the facility ensures favourable wind conditions. However, the transmission of the drive to the flour dresser turned out to be problematic. For safety reasons, as well as for conservation reasons (the interior equipment is original), demonstration of the windmill operation is limited to preparatory activities (adjusting to the wind and spreading the wooden shakes).[31]

Fig. 21: *A windmill from Dębno in the Kielce Village Museum in Tokarnia*; photo by F. Tomaszewski, October 2012.

Fig. 22: *A windmill from Zaduszniki in the Kujawsko-Dobrzyński Ethnographic Park in Kłóbka*; photo by F. Tomaszewski, July 2016.

[30] Website of the Kielce Village Museum in Tokarnia, accessed October 5, 2018, http://mwk.com.pl/pl/sg/nasze_obiekty/park_etnograficzny_w_tokarni/zespol_budownictwa_wyzynnego.

[31] According to Leszek Gawlik, an employee of the Kielce Village Museum in Tokarnia.

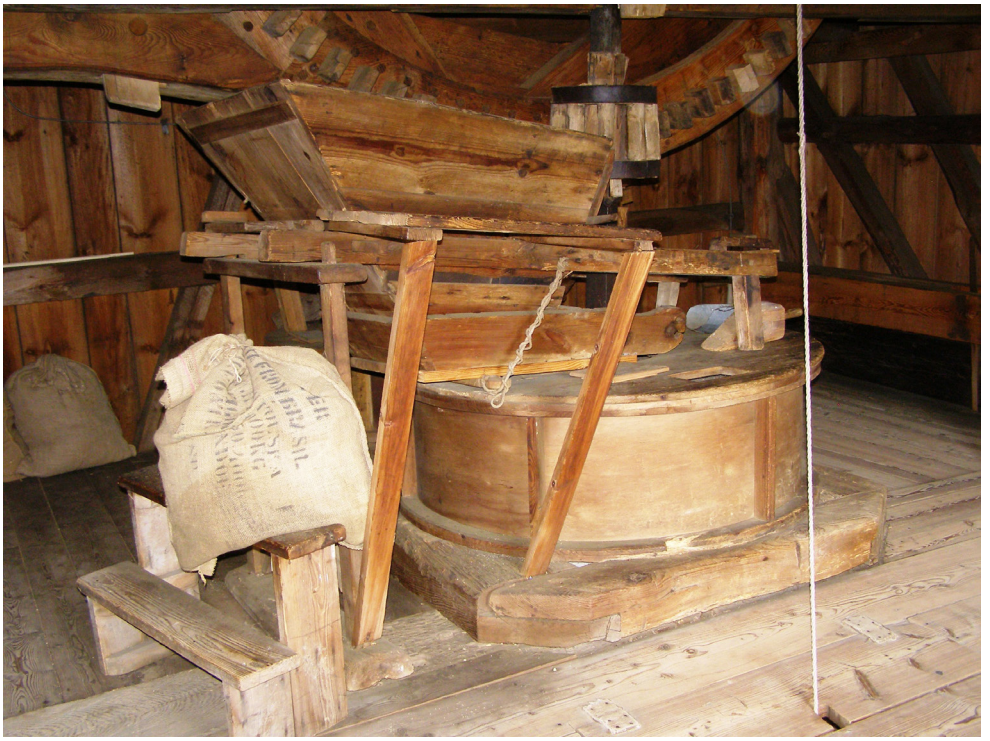


Fig. 23: *An exhibition in the windmill from Zaduszniki in the Kujawsko-Dobrzyński Ethnographic Park in Kłóbka*; photo by F. Tomaszewski, July 2016.

A windmill from Zaduszniki in the Kujawsko-Dobrzyński Ethnographic Park in Kłóbka

The post mill from Zaduszniki in the Kujawsko-Dobrzyński Ethnographic Park in Kłóbka (Fig. 22, 23), erected around 1870,[32] is operated during folklore festivals. The setting of the object with the sails to the direction of the wind is then presented, and the sails and the windshaft are also rotated. Due to unfavourable wind conditions, the sails are moved manually, after unfastening the stone nut from the head wheel (so the millstones and other devices remain stationary).[33]

A windmill from Wojtówka in the Ethnographic Museum in Toruń

The post mill from Wojtówka, dated 1896, is exhibited in the Maria Znamierowska-Prüfferowa Ethnographic Museum in Toruń (fig. 24). The windmill was translocated to the museum in 1991. It has all the equipment characteristic of this mill type and a very coherent and legible interior exhibition, including not only technological devices but also a collection of hammers and pickaxes for dressing millstones, documents related to the mill and even a bunk on which the miller had the opportunity to rest. The windmill is equipped with two headwheels driving two pairs of millstones. On the first floor, there is a flour dresser. The windmill, like the post mill from Zaduszniki in Kłóbka, has the ability to rotate on the trestle. The sails and internal mechanisms are revolved for maintenance purposes only.

Windmills from Wodziany, Ruska Wieś and Dobrocin in the Museum of Folk Architecture – Ethnographic

[32] Website dedicated to windmills in Poland, accessed October 5, 2018, http://wiatraki.org.pl/.

[33] According to Michał Kwiatkowski, an employee of the Kujawsko-Dobrzyński Ethnographic Park in Kłóbka.

Fig. 24: *A windmill from Wojtówka in the Maria Znamierowska-Prüfferowa Ethnographic Museum in Toruń*; photo by F. Tomaszewski, December 2019.

Park in Olsztynek

The Museum of Folk Architecture – Ethnographic Park in Olsztynek boasts a collection of four windmills, three of which are technically operational. These are a post mill from Wodziany, a paltrok from Ruska Wieś and a smock mill from Dobrocin.

The post mill from Wodziany (fig. 25), dating back to 1773,[34] was moved to the open-air museum in 1972–1974. In 2010, it underwent a thorough renovation. During the renovation works, a decision was made to restore the windmill's equipment to its original condition. The exhibition inside the mill includes a technological program characteristic of the end of the eighteenth century. All devices considered secondary (including mill rollers) were moved to a separate building as exhibits. After renovation, the windmill was put into operation for museum shows.[35] Unfortunately, soon after that, a serious failure occurred: the crowntree broke – the most important construction beam in the mill, suspended on the top of the main post (a vertical pole around which the buck of the mill revolves). Since the side walls of the windmill and the ceilings of the third floor are suspended on the crowntree, its replacement required the disassembly and reassembly of practically the entire building. The renovation of the windmill was completed in 2017. The windmill from Wodziany has a unique feature that distinguishes it from other windmills in the collections of Polish open-air museums: the rear (wider) side of each sail can be filled with sailcloth, while the front side has pine laths. This filling of the sails is historically justified by archival iconography. Currently (2023) the sails of the windmill must be balanced, after which an attempt to start them is to be carried out (for now, without connecting internal devices).

The paltrok from Ruska Wieś (fig. 26) was erected in the second half of the nineteenth century. It was translocated to the museum in 1976–1977. The driving mechanism of the windmill (windshaft with a head wheel) has been preserved, but the grinding devices, that is, the millstone set-up, have not been preserved.[36] For exhibition purposes, only the tun case (without millstones inside), the crane for lifting millstones and the sifter were reconstructed. After the renovation carried out in 2021, the windmill has been able to adjust the building with sails to the direction of the wind. It is also possible to rotate the sails and the windshaft.

The smock mill from Dobrocin (fig. 27) dates back to the second half of the nineteenth century. The mill was in operation until 1950. In the years 1962–1965 it was translocated to the open-air museum in Olsztynek. In 2015, as a result of a storm, the sails were damaged and had to be dismantled.[37] After this accident, the museum commissioned the necessary documentation of the renovation of the mill, which was completed in 2021–2022. Comprehensive restoration works included not only the timber-frame structure and sheathing of the windmill, but also

[34] KUFEL, Tadeusz. *Muzeum Budownictwa Ludowego. Park Etnograficzny w Olsztynku* [Museum of Folk Architecture – Ethnographic Park in Olsztynek]. Olsztynek 1999 [in Polish].
[35] CHODKOWSKA, SABLJAK-OLĘDZKA. *O wiatrakach*…, p. 34.
[36] Ibidem, p. 127.
[37] Ibidem, p. 57.

technological equipment: the windshaft was replaced, and the tail poles used to adjust the "cap" with the sails to the direction of the wind were restored. The windmill has a preserved upright shaft driving three pairs of millstones located on the first floor. After renovation, from the technical point of view, the mill is fully operational.

A windmill from Czacz in the Museum of Milling and Water Equipment of Rural Industry in Jaracz

A valuable example of an operational windmill is a post mill from Czacz, dating from 1842, currently in the Museum of Milling and Water Equipment of Rural Industry in Jaracz – a branch of the National Museum of Agriculture and Agri-Food Industry in Szreniawa (fig. 28). The object was translocated to the museum in 2008–2010. When it comes to the scope of operation of this object, the situation is analogous to the windmill in the museum in Kłóbka. Every autumn, a milling festival is organised, during which the sails are turned on and setting the building with sails to the direction of the wind is demonstrated. Unfortunately, in this case the grinding devices remain stationary.

Fig. 25: *A windmill from Wodziany (with cloth partially spread on sails) in the Museum of Folk Architecture – Ethnographic Park in Olsztynek*; photo by M. Kowalczyk, May 2018.

Fig. 26: *A windmill from Ruska Wieś in the Museum of Folk Architecture – Ethnographic Park in Olsztynek*; state as of January 2022; source: https://muzeumolsztynek.pl/wiatrak-z-ruskiej-wsi-zostal-wyremontowany/ [accessed: August 24, 2022].

Summary and conclusions

The best conservation method for technical monuments is maintaining the monument's efficiency and making its primary function clear.[38] However, it should be borne in mind that in the case of windmills, the need to maintain the use value by restoring the technical efficiency of the mill may conflict with the need to preserve the authenticity of the substance of the monument. A fundamental question arises at this point: what is the more important

[38] AFFELT, Waldemar J. *Dziedzictwo techniki w kontekście rozwoju zrównoważonego* [The heritage of technology in the context of sustainable development]. In: Szmygin, Bogusław (ed.). *Współczesne problemy teorii konserwatorskiej w Polsce*, Warszawa – Lublin: ICOMOS – Politechnika Lubelska, 2008, p. 15 [in Polish].

Fig. 27: *A windmill from Dobrocin in the Museum of Folk Architecture – Ethnographic Park in Olsztynek*; state as of May 2022; source: https://muzeumolsztynek.pl/4647-2/ [accessed: August 25, 2022].

Fig. 28: *A windmill from Czacz (with wooden shakes spread on sails) in the Museum of Milling and Water Equipment of Rural Industry in Jaracz – pictured during the milling festival*; photo by F. Tomaszewski September 18, 2011.

component of authenticity – function or substance?[39] And are they the most important criteria for the justification of authenticity? According to W. J. Affelt "The message about the purpose of the object's creation and existence is particularly important, best illustrated by its functioning, or at least by making its function clear enough to mentally reconstruct the image. This guarantees the integrity of the monument because only its completeness enables a comprehensive reconstruction of the record of history – the story of the past. An important argument of authenticity is traces of antiquity, i.e. patina – commonly removed today as part of renovation works."[40]

In the field of restoring Polish windmills as working mills, only the first steps have been taken – and most initiatives so far have encountered significant problems. The success is in the very fact that these attempts have been made. The following conclusions can be drawn from the analysed case studies:

1. Before making a decision to restore the technical efficiency of a windmill, a historical evaluative analysis should be undertaken to determine whether restoring the windmill's original function (reconstruction of the milling system) is of primary importance and possible at all.

[39] PRARAT, Maciej. *Wartość funkcji w ochronie drewnianych młynów – na wybranych przykładach z terenu Pomorza* [The value of the function in the protection of wooden mills – on selected examples from Pomerania]. In: Szmygin, Bogusław (ed.). *Wartość funkcji w obiektach zabytkowych*, Warszawa: ICOMOS – Muzeum Pałac w Wilanowie – Politechnika Lubelska, 2014, p. 236 [in Polish].

[40] AFFELT. *Dziedzictwo techniki*…, p. 13.

2. One should not try to run windmills at all costs if it would involve too much interference in the historical substance of the monument (especially in the case of in situ conservation); the most valuable objects, without a preserved full technological system, should be secured in the form of exhibits.[41]

3. When evaluating the equipment, all layers should be taken into account, including those from the period after World War II; omitting valuable layers (following the trend for conservation purism) when restoring original technological systems should be considered inappropriate.[42]

4. The technical achievements of past generations should be treated with respect – previous experience has shown that operating a windmill required a lot of practical experience; the current generation has to learn everything "anew."

5. During major repairs, the participation of specialists in the field of traditional milling technology is essential; the involvement of skilled carpenters alone is insufficient. A very important aspect during work aimed at restoring a windmill to technical efficiency is the centring of the windshaft and other drive shafts. Without it, the proper operation of gears, whether cogwheel or belt, will not be possible. It is most advantageous to mount the drive shafts on so-called self-lubricating bearings with easily adjustable self-aligning bushes. More difficult to centre are shafts bearing on fixed wooden bearings, which are often used in windmills. Activities requiring specialist knowledge and experience also include dressing (grooving) millstones, sewing transmission belts, strapping sifters and generally servicing roller mills.

6. From the point of view of use (due to unfavourable wind conditions and problems with the drive belt transmission), it seems acceptable to limit the number of machines moved by the wind to the millstones. Other equipment can be left static for safety reasons but may interfere with the readability and comprehensibility of the mill operation.

7. In the case of using an alternative, modern electric drive, the optimal solution is block drive units (engine with gear motor) located above the wing shaft in the attic area. Such a solution was used in windmills from Zalesie (in the Mazovian Countryside Museum in Sierpc) and from Grzawa (in the Upper-Silesian Ethnographic Park Museum in Chorzów). These solutions are uncomplicated and fully reversible. The engine power should be selected individually, but experience so far shows that it should not be less than 10 kW.

8. After carrying out restoration works, it is necessary to ensure the proper operation and maintenance of the mill by a trained person.

In light of the above, it is clear that launching a windmill requires specialist knowledge in various fields and that it cannot be perceived as a one-time investment. On the contrary, keeping windmills in operation not only involves continuous expenditure incurred by museums or other managers of these mills, but also above all should be regarded as a transfer of knowledge to the younger generation.

On the basis of the experiences discussed above, five main problems related to the relocation, commissioning and maintenance of historic windmills have been identified:

[41] PRARAT. *Wartość funkcji*…, p. 237.

[42] Cf.: Bazelmans, Jos, van Hof, Jan, Nienhuis, Geert, Troost, Gerard, and Pfeiffer, Wouter (2012). A Future for Mills…

1. Lack of suitable wind conditions at the new windmill sites (after relocation).
2. Risk of loss of original historic fabric due to mill improvement works (e.g., replacement of gear teeth, drive shafts, etc.).
3. Lack of specialist millwrights who would be able not only to set up the process line but also to maintain the machinery on an ongoing basis.
4. Limited possibilities to safely present an exhibition that is in motion and presents various risks to visitors.
5. The difficulty of defining the criteria for the evaluation of the windmill equipment and the related authentication of the stratigraphy (showing the history of transformations and modernisations and answering the question of which pieces of equipment should be reconstructed and put into operation).

These observations, although derived from the Polish experience, can provide universal premises for activities in the field of protection and conservation of windmills and their preparation for public opening and proper interpretation of the production process. What is more, they are strongly rooted in the concept of working museums, which has recently been very well characterised by Jamie Eves in his essay on the subject:[43] "Compared to static museums, working museums can appear noisy, chaotic, and sometimes messy. Sometimes new acquisitions pile up faster than the staff can catalog them. Exhibits rooms are in flux, as new artifacts are added to permanent exhibits (which are never really permanent), and as older changing exhibits are dismantled and replaced with new ones. There is bustle and excitement."

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[43] EVES, Jamie, *Working Museums*. https://millmuseum.org/2019/05/19/working-museums/ accessed July 1, 2024.

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