PALESTINE IN THE LATE OTTOMAN PERIOD

Political, Social and Economic Transformation

Contents

Wind Power in the Technological Development of Palestine

SHMUEL AVITSUR

Mankind's first motor — the horizontal waterwheel — originated in the geographical area of Palestine; and along with it there developed a number of rather sophisticated ancillary installations (rising basins, aruba-penstock, etc.) which made this wheel highly efficient in its exploitation of available water power. When equipped with iron-bound wheels, as in the late 19th century, the horizontal mill attained an exploitation efficiency of nearly seventy percent. In contrast to the thorough exploitation of water power in Palestine, the energy latent in the wind or in moving air was scarcely tapped for productive purposes (except in the winnowing of grain or the artificial creation of draught by means of hand-operated bellows). The only really effective exploitation of wind power was in transportation (i.e. sailing ships).

The windmill probably originated in Persia. Like the early local waterwheel, these first windmills were horizontal, that is they had a horizontal wheel on a vertical shaft turned by mat sails. Exploitation of wind power for productive purposes (especially milling) was widespread in Europe long before it was attempted in Palestine. In fact, the earliest attempts to introduce the windmill into the country coincided with the beginning of the industrial revolution in Europe.

Evidence about the existence of windmills in Palestine is found from about the second quarter of the 18th century onward in various literary and documentary sources. The earliest indication comes from the Englishman Richard Pococke's book of eastern travels.[1] He mentions a ruin on the Mount Scopus — Mount of Olives range in Jerusalem — which was known to the local people as "the windmill" and he therefore marked the site "Windmill Hill" on his map. The Italian Giovanni Mariti, who visited Palestine and other Near Eastern countries in the third quarter of the 18th century, and wrote about his travels, mentions that there was a windmill at Acre.[2] De Volney, a French savant and the head of the Marseilles Chamber of Commerce, wrote of a windmill at Ramle which apparently had been constructed by Venetian carpenters.[3] All the above references to windmills in Palestine date from the middle and second half of the 18th century. In the last two cases the evidence is quite clear and unequivocal: the references are to actual windmills seen by the writers themselves on their respective visits. However, in regard to the Jerusalem windmill there is only the legend on Pococke's map, though it may be strongly assumed that there had been a windmill on the site. In any case,

these were the first indisputable references to industrial wind power exploitation (i.e. grain milling) in Palestine. It is doubtful that these windmills were active for any length of time, since no further reference to them after the 18th century has been found.

An apparently officially promoted scheme to construct a number of windmills to supply military personnel as well as civilians with flour is recorded from the period of Muḥammad 'Alī's rule in Palestine (1832-1840). The diary of the Greek monk Neophytos[4] reveals that Muḥammad 'Alī had appointed his stepson Ibrāhīm Paşa commander-in-chief of the "Egyptian" military forces in the Levant; and it was seemingly the latter's initiative which resulted in the construction of a windmill in the Jerusalem area. The existence of windmills in Jerusalem at that period has been confirmed by G. Dalman's researches made at the beginning of the 20th century. The Armenian community also constructed a windmill, mainly for its own use, inside the walled area of Jerusalem. The windmill which was located in the garden of the Armenian monastery, began to operate a few days before Ibrāhīm Paşa's windmill on Mount Zion, even though its construction was started some time after the latter's. Other windmills in the Jerusalem area were sited north of Shu'fāt (the ruins of this windmill were seen by Dalman), near 'Ayn 'Arīk, and on the summit of al-Bīra.[5] The latter windmill, no longer preserved, is commemorated in the name given to this summit on modern maps: Ra's al-Ṭāḥūna (summit of the mill). In the 1930s this became the site of the first broadcasting transmitter in Palestine.

In all probability these windmills were of the classic Mediterranean type, known as "Aegean" windmills, which are equipped with cloth sails suspended on masts like the sails on boats. The movable cap of these mills could be turned towards the wind by means of a longer lever pole. In an article published in the early part of this century, the architect Conrad Schick, a renowned researcher of Jerusalem's history and a long-time resident of the city, mentions that Ibrāhīm Paşa's windmill was furnished with large millstones originally brought from Gaza. Because of their great weight these stones could not be transported in the usual manner on camel back; instead they were rolled along the ground all the way to Jerusalem by specially recruited teams of fellaheen.[6] This windmill had a short working life, probably scarcely more than one year (it began to operate at the end of August 1839, while Muḥammad 'Alī's rule in Palestine did not outlast the year 1840). After Ibrāhīm's troops pulled out of Jerusalem, the windmill was destroyed by an enraged mob.[7]

In fact, this deed by the Jerusalem mob signaled the end of what may be called the second phase in the effort to exploit wind power for industrial purposes in Palestine. It is advisable to make a sharp distinction between the two early phases in the endeavor to utilize wind power in Palestine: in the first phase the windmills were built by local commanders or officials (*aǧa* of Ramle, Ḍāhir al-'Umar at Acre) to supply the local demand for flour, while those built in the second phase belonged for the most part to the far-reaching scheme of

technological innovation drafted by Ibrāhīm Paşa for the territories under his control. The local windmills were set up in places where water power to drive watermills was not available. Furthermore, they were meant, in combination with the watermills, to raise flour milling (a traditionally female domestic task) to the level of an industry, or at least a protoindustry.

The third phase in the story of wind power utilization in Palestine is intimately associated with Sir Moses Montefiori. When Montefiori visited Jerusalem in 1839 he was already informed about the existence of two windmills (i.e. Ibrāhīm Paşa's and the Armenian windmill); moreover, it may be assumed that he learnt about the other windmills then being constructed to the north of the city during that visit. Nor could the fate of these windmills (i.e. the destruction of one [Ibrāhīm's] and the failure or near failure of the others) have escaped his notice on his later Jerusalem visits. If at the time he asked himself (as he may well have done) why these windmills fell so far short of expectations, he would probably have concluded that the cause of failure inhered in the windmills themselves: the "Aegean" windmill with its low output, light construction and inefficient wind power exploitation simply was not adequate to meet the demands of large-scale grain milling and could not compare in performance to the advanced European windmills. At all events, on one of his later visits to Jerusalem, in 1855, he decided to enlarge the scope of his activities for the welfare of its Jewish community (which earlier had included a scheme to set up a weaving shop for training *yeshiva* students as weavers) by adding one essential industrial enterprise, namely a grain windmill. This windmill was to be of the most modern and technically advanced type then available in Britain.

The construction of the windmill proved a troublesome enterprise: first the Ottoman ordinance prohibiting building within a certain distance outside the walls of Jerusalem had to be overcome; then there was the difficulty of transporting the various parts of the windmill from the beach at Jaffa to the site at Jerusalem; and finally one had to contend with fierce oppositon from the owners of the horse-powered mills who feared (justly enough) that the new windmill would deprive them of their livelihood. This led them to some desperate measures; they not only tried to interfere with the actual construction of the windmill but also summoned a sorcerer to cast spells in order to avert the impending "disaster" and by his curses and maledictions prevent the operation of the mill. But, as often happens in such cases, both the hopes of its supporters and the fears of its opponents were proved excessive. As ordained by Montefiori, all the mechanical equipment of the windmill — of the latest and most advanced design — was ordered from a British manufacturer. With the steam engine in the ascendant, much ingenuity was expended at the time to improve the efficiency of windmills. Equipment of this advanced type had so far been installed in only a minority of the windmills in Britain itself. The equipment was designed for a solid, stone-built tower mill with a movable cap that could be turned into the "eye of the wind" by means of an automatic

fantail. This fantail, which is usually mounted at the tail pole, is really a miniature windmill that turns the roller-mounted cap on its steel runners. The mill cap carries the shaft on which the sails of the windmills are mounted. So long as the mill faces squarely into the wind its sails revolve and through a system of gears activate the grinding machinery. But once the wind changes direction it loses its grip on the sails of the mill, which then comes to a stop. At this point the automatic fantail comes into action since its vanes, which formerly had their edges to the wind, are now rotated and so begin to turn the cap until its sails once again face squarely into the wind. At the same time, the vanes of the fantail revert to being edge-on to the wind and cease turning.

Two windmill specialists, one of them an architect of windmills (apparently both came from Canterbury, the neighboring city to Ramsgate where the Montefiori estate was located), were commissioned to install and assemble the mechanical equipment and supervise the running-in of the mill. According to a contemporary account published in the London *Jewish Chronicle* it needed forty men to transport each major piece of equipment from the Jaffa beach to the site of the windmill. The transfer of the equipment and its installation in the newly built windmill tower took some four months. The windmill, which even today looms high above the low roofs of the Mishkenot Sha'ananim and Yemin Moshe neighborhoods, rises to a height of 50 feet (ca. 15 m) and the wall of its base is 3 feet (91 cm) thick.[8] A sum of £1450 or $7250 (at the contemporary rate of exchange) is reported to have been spent on the windmill. It is not clear, however, if this sum was for the equipment only or included also the cost of constructing the tower.

Notwithstanding the sorcerer's maledictions, the fears and misgivings of its competitors, and past disappointments in this field, the windmill started on its career. We know from contemporary evidence that the windmill was equipped with four sets of millstones. Of course, the earlier type of mill with wood-frame cloth sails could never have been equipped with this number of millstones. These earlier windmills had four sails of cloth which could be furled and unfurled like the sails on a boat. Thus when the windmill was not required to operate its sails were completely furled, while at other times, if too stiff a breeze risked overrunning of the mill, its sails were reefed to slow down its rotation speed.

Montefiori appointed a lessee for the windmill who was required to operate it on his own responsibility, that is at his personal financial risk. The price fixed for milling one *roṭel* (2.88 Kg) of grain undercut the customary price charged by the horse mills by two *paras* (1 *para* = 1/40 part of a piaster). In other words, the windmill's price for milling one ton of grain was cheaper by 15 piaster than the price of the competing horse mills (each family milled approximately 70-90 kg of grain per month).

It is known for certain that the windmill was in operation in 1858 (it may even have begun to operate in late 1857), but it had definitely ceased to operate by 1887 when A.M. Luncz wrote about it in the second volume of his annual

Yerushalayim (Jerusalem).[9] In a travel diary entry (dated 6 August 1874), made during his last stay in Jerusalem, Montefiori mentions that he visited the windmill and climbed up into the mill-cap where he found everything well maintained, except the grindstones which were "quite worn", though this did not seriously interfere with their milling action. Therefore, we have definite evidence that the windmill was active for at least a period of 16 years; furthermore, it is most likely that it operated for not less than twenty years, though probably with interruptions.

This first modern windmill in Jerusalem, constructed on the initiative of Sir Moses Montefiori (and apparently entirely financed by him), was soon followed by other windmill projects. Chronologically the earliest of these (and probably directly inspired by Montefiori's example) were the windmills constructed by the Greek Orthodox Patriarchate on a site owned by it near the Old City of Jerusalem (in the area of today's Reḥavya). This site, on higher ground, was better suited to exploit the prevailing winds than the site of the Montefiori windmill. Apparently the Greek Patriarchate's windmills were conceived as a strictly business venture.

Rephaim, the German Templar colony in Jerusalem, was started in 1870 and almost at the same time a windmill was erected there. This windmill operated for only a short period. A low-profile windmill (today no longer visible because of modern high-rise buildings nearby) was erected in the courtyard of the Ratisbonne Catholic Foundation (1874) in Jerusalem.[10] No information has been found as to how long this windmill functioned, nor for whom it was destined (presumably, it was not for the people of the Foundation itself). At all events, its original industrial purpose was soon forgotten; not long ago there appeared an article in one of the local newspapers which rather fancifully described the surviving structure of this windmill as a "beacon tower", designed for communication by light signal with the port of Jaffa.[11] The fact that the windmill is not in line of sight with Jaffa port did not apparently trouble the journalist in the least.

In one of his recent books on his childhood and youth in Old Jerusalem, (*Yerushalayim tmol shilshom*), Ya'aḳov Yehoshu'a mentions the windmills of the Greek Orthodox Patriarchate. As told to him by one of its priests, the Archimandrite Daniel, there had been in the past (the time referred to is just over a century ago) four windmills in the new town of Jerusalem belonging to the Greek Patriarchate (that is, three more in addition to the one surviving windmill). At first blush, this would seem to be an exaggerated number; yet if one examines the map of Jerusalem in Baedeker's travellers guide of 1876 one sees that actually *five* windmills are marked on it, all located outside the Old City walls on the west side. These windmills included the "Montefiori Windmill", sited on the highest point of Mishkenot Sha'ananim; also a windmill in the Ratisbonne Foundation's grounds; and somewhat farther west, though fairly close by and still within the area of today's Reḥavya neighborhood (the ground of which once belonged to the Greek Orthodox

Patriarchate) two windmills located side by side at some 450 meters from the surviving windmill near today's Kings Hotel. With regard to a possible third windmill of the Orthodox Patriarchate (or fourth, if the above-mentioned disused windmill is taken into account) no site has yet been identified. From all this it may be concluded that the number of windmills in Jerusalem in the 1870s was far greater than hitherto imagined; but this expansive development came to a halt and was almost totally reversed during the 1880s and 1890s.

Almost all the windmills in Jerusalem at this period were constructed to provide the inhabitants of the city with increased grain milling facilities, since the existing horse-powered mills could not cope with the growing demand.

In this same period a few windmills were also erected outside Jerusalem in other parts of the country (which have left their toponymic reminder in the shape of further Ra's-al-Ṭāḥūna hill tops). The last of these windmills outside Jerusalem was erected by the German Templars near Haifa's seashore (the area of today's Bat Galim). It must be admitted that for the most part these windmills were not notably successful, which not only discouraged the construction of further mills but inhibited the operation of the existing ones.

As yet, there has not been any serious analysis of the causes that led to the disuse of these windmills (nor, for that matter, do we really understand what led to their construction in the first place). From the little information on the subject in the annual reporting on developments in Palestine by Luncz, Graevsky and others, it has been construed that the disuse of the windmills was directly linked to the arrival of the steam mills. But this is an oversimplification. The truth seems to be that windmills were introduced at the end of a transitional period of development which had begun earlier and was logically destined to lead to the complete mechanization of grain milling. Lack of data and the passage of time now make it difficult to follow this transitional development for particular localities; nevertheless this should not prevent us from charting its course through the country generally.

From the little that is known of the Montefiori windmill it may be inferred that its lessee did not properly attend to its maintenance and, moreover, was inclined to a certain lack of moral scrupulousness. He was perpetually requesting money for repairs and allowed the mill to stay idle until the money arrived, whether from genuine inability to finance the repairs himself or as a means to pressure his patron and master is unclear — though one may guess that both factors were involved. Somehow he managed to make it appear as if he was doing his patron a favor each time the windmill resumed operation. There is also the suspicion that few of the Jerusalem craftsmen were expert enough to carry out the repairs; this meant that some of the work had to be sent outside and spare parts had to be obtained from abroad. But apart from these human shortcomings there were purely objective reasons, related to specific local conditions, as to why this windmill did not perform as well as had been anticipated, and evidently the planners and builders of the windmill had not bothered to inform themselves beforehand of these conditions.

Wind conditions in Jerusalem with their relatively low velocities and irregular frequency throughout the year could not guarantee the continuous operation of windmills there; this applied especially to the Montefiori mill which was sited inconveniently on a point below the highest elevation in the area surrounding the Old City walls. But probably the major cause of failure was technological: the machinery of these windmills was designed for milling the soft European wheats, which required less power (i.e. wind strength) than grinding the local hard wheat used for bread making in Palestine. As a result these windmills were only poorly utilized since wind strengths were rarely adequate to overcome the resistance induced in their grinding machinery by the hard wheat. One can easily imagine the frustration and impatience of customers forced to wait for a strong enough breeze to activate the mill's machinery and grind their wheat. There were probably not more than twenty days in the year when the mill's four sets of grindstones could be operated together. At other times there was perhaps just enough wind to drive one set. But often there was no wind at all, or it was too feeble to drive even one set of grindstones. This meant that milling a given quantity of grain considerably exceeded the time normally allowed for it, sometimes as much as two or three times.

The first steam mill in the country was put into operation in Jerusalem in 1878; but even sometime before this, while the remaining windmills struggled to keep going in rather unsuccessful competition with the traditional beam mills, there had been introduced a viable alternative to both the windmill and the horse-driven grain mill. This was the horse treadmill. Unlike the windmill, the treadmill was independent of the wind conditions and, with relays of horses, could be operated round the clock. Moreover, in comparison with the traditional horse grain mill its output was larger, while the price per unit weight of grain milled was approximately the same.[12] Since the primary investment of the Montefiori windmill (i.e. construction of its tower, mechanical equipment, etc.) had been provided by the philanthropic initiator of the project, its lessee-operator only had to meet the costs of the day-to-day running of the mill. But this did not apply to the other modern windmills (e.g. the Greek Orthodox Patriarchate's windmill) whose owner-operators had to finance the construction and equipping of their windmills out of their own funds without the benefit of a philanthropic patron. They found the financial investment to be a heavy burden; while the windmill, once in operation, held out little hope of a profitable return. There is evidence to suggest that the windmills of the Greek Orthodox Patriarchate were replaced by a treadmill.

This third and final phase in the history of the grain windmill in Palestine virtually ended in the early 1880s. But not altogether, for there was a continuation in the form of two windmills in Haifa, on adjacent sites, which operated (at least intermittently) until the time of the British conquest in 1917. The earlier of these two windmills was put into operation already in 1872. What ensured these mills their long operating life was the fact that a steam (or

kerosene motor?) mill had been integrated with them. Because of this their customers were assured of continuous service, since during the windy part of the day (usually most of the afternoon) the windmill units could be operated while during the wind slack hours one switched to the steam mill. This arrangement was basically similar to that of the combined grain mills operated in Europe and the United States during the second part of the 19th century. Later, integrated mills (i.e. kerosene motor and windmill) became more common as, for instance, the windmill near today's Kings Hotel in Jerusalem.

From information supplied by Shmu'el Grupper (born in Zikhron Ya'aḳov, where his father had been the baker) it is evident that not all the customers of the Haifa mills came from the German colony and the town of Haifa. As told by him, the householders of his native village regularly took their grain to be milled at the Haifa mills, and for this purpose they would form into a party which set out before nightfall in order to reach the mills by early morning. They transported their grain in carts which, immediately after arrival, they unloaded. After weighing and bagging their grain they stacked it ready for milling. This done, and having unharnessed and fed their draught animals, they had time on their hands which they used to go shopping in town. Returning, they might find that some of their people's grain had already been milled, while that of the others was still waiting to be tipped into the hoppers. But they delayed their departure until everyone's grain had been milled, as they were determined to return in one convoy the way they had come. Why they should have preferred to go all the way to Haifa when they had a large water-powered grain mill nearby (on Naḥal Taninim [Crocodile Rivulet], near today's Kibbutz Ma'agan Mikha'el) is difficult to understand, but perhaps explained by the fact that the track to the Taninim mills was virtually impassable to carts.

To sum up, it would appear that the grain windmills in Palestine during the three major phases of their existence (second half of the 18th century; period of Muḥammad 'Alī's rule; third quarter of 19th century) were never more than of marginal importance in the context of available milling facilities. This applies even to their peak phase, during the 1860s and 1870s, when modern windmills of European manufacture were introduced. Though technologically advanced, these windmills were capable of reducing only slightly, and not for more than a short period, the gap that was opening between the demand for flour (caused by the growing urban population) and the capacity of the existing milling facilities to supply it. Due to its large Jewish element, Jerusalem, which at the beginning of the 19th century had only some 8000 inhabitants, had grown by mid-century to be the country's biggest city. At the beginning of the 20th century it already had a population of nearly eighty thousand. The problem of milling facilities was particularly acute in Jerusalem. It was less so in Haifa, where at least the inhabitants of the surrounding villages had access to the Kurdaneh water mills on the sources of the Na'aman river. However, this possibility was not open to the town dwellers without pack animals (the great majority); these had to make use of the animal-driven grain mills (milling one's

grain became easier once a steam or kerosene motor mill was added). In the *Survey of Western Palestine* the Haifa windmill is described as being of the Dutch type, but equipped with English-made gearing and grinding machinery.[13] The flour produced by these modern windmills was apparently superior in quality (i.e. probably finer ground) to that of the horse-driven grain mills.

It should not be thought that the utilization of wind power for industrial purposes was restricted only to grain windmills. Wind power was also utilized for pumping water, though this had to await the development of the wind turbine in the United States. Basically the wind turbine consists of a number of small iron vanes set radially in a wheel (similar in design to the impeller wheel on the local horizontal water mills); later, during the Mandatory period, wind motors equipped with propellers were introduced. Both types of wind motor operate at wind strengths lower than those required by conventional windmills. The initial introduction of the wind turbine during the 1880s coincided in fact with the beginning of the phasing out of the conventional grain windmills. At this stage wind motors were used only for water pumping.

Until the introduction of the wind pump, drinking water had generally been drawn from a well by one of three methods, all involving the use of human muscle power. They ranged from the simplest: drawing up the bucket manually on the end of a rope, which sometimes passed over a pulley; via the use of a hand wheel for winding up the bucket rope; to the use of the tread wheel (operated by the simultaneous push-pull action of the drawer's arms and legs, reinforced by his body's weight). When more than just drinking water was needed (for various domestic purposes; irrigating small plots such as kitchen gardens, etc.) two additional water-raising methods were available. The swipe or *shādūf* was manually operated and used primarily to lift water from shallow wells and streams. On the other hand, the inclined plane lift exploited animal power and was designed for water raising from deep wells. The much larger quantities of water required for irrigating citrus plantations or meeting the consumption needs of entire villages were supplied by animal driven *antilias* (Persian wheels). The *antilias* were equipped with endless chains of pottery scoops or wooden scoop boxes; but there was an effective limit to their lifting capacity (ca. 10 meters depth) beyond which even the strongest animal (i.e. camel) could not raise the water-filled scoop pots or boxes.

When W.F. Lynch, the American naval officer who made a scientific survey of the Dead Sea, visited Jaffa in 1848 he met there his country's consular representative, the Armenian Murād. Apparently Murād owned a citrus plantation that was irrigated by a Persian wheel (*antilia*) through a network of open channels. To mitigate the heavy loss of water due to this network of open channels, Lynch advised his host to install a wind pump instead of the Persian wheel. But the advice was premature, falling on deaf ears.[14]

Another attempt to install a wind pump in a citrus plantation was made a short time after the Lynch-Murād meeting. The person concerned was Rabbi

Yehuda Halevy of Dubrovnik (Ragusa) who settled in Jaffa in 1832 as rabbi of its small Jewish community and also acted as the local representative of the Jerusalem community organization and rabbinate. It is reported that he bought (according to some sources, also planted) a citrus grove near Naḥal Ayalon (Brook of Ayalon). In a letter to Sir Moses Montefiori, dated 28 July 1853 and written in English, he requested Montefiori to send him a wind-driven water pumping machine, of the kind he had heard about from local Amercian settlers (who had established a farm settlement on Mount Hope, not far from Halevy's grove); he added that if a machine of this type became available to him he could irrigate another four gardens (i.e. groves) with its aid.[15] Montefiori failed to respond to this request; however, at a later date he bought the grove from Halevy which became the "Montefiori Plantation", eventually the Montefiori Quarter, today an integral part of Tel Aviv-Jaffa.

When the German Templars established their agricultural settlement Sarona in the coastal plain near Jaffa (today part of the municipal area of Tel Aviv-Jaffa) they dug a communal well to provide the settlement's water supply. They had to dig down to 24 meters before reaching groundwater — far too great a depth for water raising by animal-driven *antilia*. Because of the cost the use of a steam pump could not be entertained; moreover, recent experience with the Bergheim steam mill in Jerusalem had painfully demonstrated the disadvantages (high fuel costs, lack of water for the boiler during part of the year, maintenance difficulties due to lack of trained mechanics, etc.) of steam-powered installations in this, as yet, very underdeveloped country. Since neither animal nor steam power would do, it was found that the answer was wind power. A wind turbine erected on top of a steel pylon (a much cheaper construction than the conventional, stone-built windmill tower) driving a water pump. This wind pump was first installed in 1879, that is almost at the end of the settlement's first decade. From contemporary evidence we know that the wind pump operated continuously (except during windless periods of course). The water was pumped into a reservoir and from there transferred through pipes to the settlers' courtyards.[16]

Some three years after the installation of the wind pump at Sarona the founding settlers of Petaḥ Tiḳva had to find the most suitable means of pumping from a deep well. Plagued by malaria and various other illnesses, they decided to transfer their settlement to another healthier location (Yehud) where they built permanent houses and dug a communal well. With its 46 meters' depth, this well was much deeper than the well at Sarona. As a matter of fact, the idea of a wind pump had already occurred to the Petaḥ Tiḳva founders when their future settlement was yet in the planning and discussion stage; they even incorporated it in their statutes which mention the possibility of pumping water by means of "a wheel turned by the wind". With the help of a money donation, they purchased and installed a wind pump of similar model to the one at Sarona — but first had to deepen their well to 52 meters. The total cost of this water installation (i.e. sinking of the well, wind turbine and pylon, water

pump, etc.) was 12,000 francs (4800 rubles or 2800 dollars). At the time it was optimistically — and mistakenly — thought that this wind pump could also provide water for irrigation (especially to irrigate a grove of citrons the settlers had planted). Even more mistaken was the notion that the wind motor could be utilized for grain milling. This wind pump continued in operation even after the original Petaḥ Tiḳva settlers left the village and allowed squatters to take over the houses. The Bilu pioneer H. Ḥisin, writing in a contemporary Russian-Jewish journal, relates that when he visited Yehud in 1895 the only sign of life he saw in all the village was the revolving wheel of its wind pump, perched on its tall pylon like some "fantastic bird of prey". The wind pump at Yehud had a fairly short life, for apparently some time around 1900 it had already disappeared.[17] At least, so we learn from Shim'on Kushnir, the son of one of the families later settled in the village, who recalls that his people got their water from the local well by the age-old, hand-drawing method.

Water pumping by means of wind motors is also mentioned in the Russian language pamphlet "Description of the Jewish Settlements in Eretz Yisra'el" by Merowich, which includes factual and statistical information on these settlements.

The wind pump at Yehud was the first such device to be installed in a Jewish settlement (and the second wind pump in the country altogether), though apparently it had been preceded by several (unrealized) projects for wind-powered water pumping installations at other places. In one case we have the evidence of the contemporary map of Miḳve Yisra'el in its founding year (1870) (this map is reproduced in the centenary publication of this famous agricultural school, edited by Yosef Shapira). One spot on this map is marked "windmill", that is a wind-powered installation (whether grain windmill or wind pump is not clear) was intended to be erected at the spot. Yet despite the legend on the map, evidently indicating the planners' intentions, no wind-powered installation was ever erected at Miḳve Yisra'el.

Two other unrealized projects for utilizing wind power in the Jewish settlements were: 1) a scheme to utilize wind power to irrigate the agricultural lands of Petaḥ Tiḳva and 2) a plan to install a wind pump at the first well of Rishon le-Tziyon, because of that well's "unreasonable depth", which made it unsuitable for water raising by animal-driven *antilia*. Brill tells us that the settlement lacked the money to purchase a wind pump, and therefore Joseph Feinberg was sent to Europe to persuade likely benefactors to provide loans for this purpose. Although unsuccessful in this, he proved persuasive enough to sway the heart of one generous donor, Baron Edmond de Rothschild, who in later years invested millions on the tiny developing Jewish community in Palestine.[18] Though Rishon le-Tziyon would remain without a wind pump, there was to be a vast injection of capital that drastically changed the scale and pace of Jewish development in the country, and indeed its effect was felt until the outbreak of the World War I.

Another wind pump in a Jewish agricultural context existed at Aaronsohn's

experimental agricultural station at 'Atlīt. This installation, which operated on the average eight hours in every twenty-four-hour period,[19] was more powerful and of larger capacity than the wind pump at Yehud. Wind pumps were also installed at various nonagricultural locations. One of these was at the German Templar settlement in Haifa (for domestic water supply); while another (unsuccessful) wind pump was erected in the area of today's Zion Square in Jerusalem.[20]

At a somewhat later period a wind pump was installed at the spring near Metula, a Jewish village in Upper Galilee. This installation was financed by the Jewish Settlement Organization (YICA). For economic reasons a wind pump was preferred to a motor-powered pump, since its operation required neither fuel nor a special attendant. A main pipe conveyed the water from the spring to the village, where it was distributed through subsidiary pipes to the individual homesteads. Unfortunately this water supply did not perform well. The breeze was not always strong enough to properly activate the wind pump (which moreover had been erected in a comparatively low-lying spot) and consequently there was a lack of pressure in the pipes and often no water in the taps. In an attempt to overcome this shortcoming a small reservoir was built at the highest point in the village and the inhabitants drew their water from there. But even this arrangement did not work out, because of the frequent breakdowns of the wind pump which the village smith was unable to repair satisfactorily. So the villagers abandoned their "windmill" and went back to the old way, that is trekking to the spring and hauling the water back to the village in tin canisters loaded on donkeys. A wind turbine also existed at the German Catholic monastery near 'Eyn Sheva' (al-Tabḥa, today Karey Deshe), which in addition to driving a water pump also powered some machine tools in the monastery's metal workshop.

However, the main use for wind-powered pumping installations was found along the tracks of the Hijaz Railway, especially along its section through the Transjordan desert and southward to Medina. At every desert halt with a nearby well a wind pump and a water tank on stilts were installed. A similar wind-powered water installation was also constructed at the Haifa terminus of this railway. When the British built the standard-gauge railway from Ḳanṭara to Haifa (the Turkish-built Hijaz railway was narrow gauge), which passed through the Sinai desert, they also installed wind pumps and water tanks at the halts along this line. The Circassians, who had been settled in the Golan region by the Turkish administration, also made use of wind-powered water pumping installations, especially at Ḳunayṭra. But these were a reversion to an earlier type — "Aegean" cloth-sail windmills, here adapted to pump water from the shallow wells in this region.

Yet, despite the above-mentioned examples of wind-powered water pumping, the use of such installations in this country was rather limited, especially in comparison to Cyprus or Crete. This lack of enthusiasm for wind-powered installations can be explained on two grounds. On the one hand, the initial

investment for installing a wind pump was quite considerable; and on the other hand, there was always the risk that irrigation water would be lacking at the very time it was most needed, that is during the critical growing period before the harvest. While two to three days' water supply could always be stored for a limited purpose, as on the railways, this was not feasible where irrigation water was concerned since the quantities involved were too large to be stored by individual farms. Hence, a week's interruption of the breeze could prove fatal to the crops. This explains why, despite the superficial attraction of a "costless" source of energy, the wind pump failed to take hold in this country.

During World War I there was a half-serious attempt to utilize wind power for the propulsion of a rail car. Members of a German air force unit, stationed at the time at Merḥavya near 'Afula in the Jezreel Plain, commandeered a flat car belonging to the Hijaz Railway, on which they mounted a mast and sail, and so created a wind-propelled rail car. They used this vehicle, which they facetiously dubbed "Phönizischer Badeexpress" (Phoenicia Bath Express)[21] to transport them on their furloughs to the "metropolis" of Haifa (a very small town, at that time). Of course their contrivance was more ingenious than effective, since the wind rarely blew in the right direction (the prevailing wind is westerly, in the direction Haifa-'Afula), and so they were condemned to frequent waits and interrupted journeys. Eventually this shortcoming was put right by a Jewish engineer, Baruch Katinka, who mounted an aircraft engine, "borrowed" from the German unit, on the rail car — which admittedly made its journey independent of the wind direction, but also, somewhat less of a lark.

Notes

1 R. Pococke, *A Description of the East* (London, 1748), vol. 2, part 1, p. 29 and map (after p. 6).
2 G. Mariti, *Voyages dans l'isle de Chypre, la Syrie et la Palestine* (Neuwied, 1791), tome 2, p. 94.
3 C.F.C. de Volney, *Voyage en Syrie et en Egypte pendant les années 1783, 1784 et 1785* (Paris, 1787), vol. 2, p. 308.
4 Neophytos, Monk of Cyprus, *Annales of Palestine, 1821-1841* (Jerusalem, 1938), p. 131. A partial translation was published in *Journal of the Palestine Oriental Society*, 13 (1938).
5 G. Dalman, *Arbeit und Sitte in Palästina* (Gutersloh, 1933), vol. 3, p. 251.
6 C. Schick, "Die Baugeschichte der Stadt Jerusalem", *ZDPV*, 17 (1894), p. 265. Schick mentions two windmills, but there is no contemporary evidence (i.e. from 1830s) to conform this.
7 Neophytos, p. 134.
8 *Ha-Magid*, no. 2, 7th Shvaṭ, 5619 (1859), p. 7 also quoted by S. Sheva in his *Eretz Tziyon vi-Yerushalayim* (Jerusalem, 1973), p. 26. See also A.M. Hyamson, *The British Consulate in Palestine* (London, 1939), part 1, pp. 258, 262-264.
9 *Yerushalayim* (ed. by A.M. Luncz), vol. 2, 5647 (1887), pp. 125-126.

10 Possibly this windmill also appears on Schick's map of 1879, included in his article "Das Land zwischen Jerusalem und dem Todten Meer", *ZDPV*, 3 (1880). See also K. Baedeker, *Jerusalem and its Surroundings; Handbook for Travellers* (London, 1876), pp. 100-101 (1973 reprint).

11 Amos Levav, "She Lives in a Four Hundred Years Old Beacon Tower", *Ma'ariv* (August 13, 1976), in Hebrew.

12 For details on these treadmills, see S. Avitsur, "ha-Midrakhiyot ba-aretz", *Teva' ve-Aretz*, vol. 3, no. 3 (1961), pp. 126-132.

13 C.R. Conder & H.H. Kitchener (eds.), *The Survey of Western Palestine, Memoirs*, vol. 1 (London, 1881), pp. 283, 356. These windmills appear on the map of Haifa in Baedeker's *Palestine and Syria* of 1912.

14 W.F. Lynch, *Narrative of the United States' Expedition to the River Jordan and the Dead Sea* (London, 1841), p. 441.

15 S. Halevi, "Pardes Montefiori", *Cathedra*, 2 (1976), p. 162 and p. 165.

16 F. Lange, *Geschichte des Tempels* (Stuttgart, 1899), p. 818. See also *ZDPV*, 6 (1883), p. 40.

17 A.M. Luncz, *Luaḥ Eretz Yisra'el li-shnat "tarsab"* (Jerusalem, 1901), p. 12.

18 I. Brill, *Yesud ha-Ma'ala* (Mainz, 1883), p. 164 (in Hebrew).

19 S. Tolkowsky, *What We Have Achieved and For What We Hope in Eretz Yisra'el* (Petrograd, 1918), p. 31, in Russian.

20 *Palästina* (1912), photo on p. 42.

21 Pinhas Pick, "Meissner Pasha: ḥalutz ha-rakavot be-Eretz Yisra'el u-shkhenoteha", *Cathedra*, 10 (1979), p. 128.