The nuances of the organizational preparation the electrification of the Kharkiv plant of the Russian Locomotive-building and Mechanical Society (1895–1896)

Abstract. The transition to an electromechanical drive of equipment has become a new milestone in industrialization, which has led to significant: an increase in labor productivity and a decrease in the energy intensity of production processes. But on the Ukrainian lands of the Russian Empire, this innovation was not introduced until the mid-1890s, and only since that time the process of electrification of production at Ukrainian enterprises has been developed, however, with a simultaneous retain the steam-mechanical drive of equipment also. The Kharkiv plant of the Joint-Stock Company Russian Locomotive-building and Mechanical Society became the first enterprise not only in the Ukrainian provinces of the Russian Empire, but throughout the country, which used solely an electromechanical drive for all equipment. Taking into account this priority, the organizational preparation for the process of electrification of this enterprise also became the first experience in the country of introducing such an innovation, comparable, perhaps, only with the experience of switching from a mechanical to a steam-mechanical drive, which, however, was not studied in the Russian Empire. Simultaneously, the level of technical literacy of a part of the management of the Joint-Stock Company Russian Locomotive-building and Mechanical Society was not high enough to give a technical and economic assessment of the relevant innovations. Therefore, the organizational preparation for the electrification of the Kharkov plant of this Society was carried out without any clear...
methodological approaches, which in the discussion regarding the electrification scheme of the enterprise led to the replacement of the issue of choosing the best option from the most effective ones to the question of choosing the best one from the cheap ones. As a result, the Society's experts developed terms of reference for a compromise version of the electrification project, the essence of which was to install relatively new electrical equipment in terms of technical level, but operated according to an already outdated scheme, which made this electrification option neither efficient nor cheap, but politically acceptable for the entire leadership of Society. Eventually, it was possible to achieve the expected benefits from the electrification of the plant not from the implantation of the chosen scheme for its implementation, but by concluding strategic agreements with Siemens & Halske, according to which the Company's Management Board ensured it won the competition for the electrification of Society's enterprise at an affordable price, and Siemens & Halske, in turn, subsequently supplied the Company with its products at significant discounts.

**Keywords:** electric drive; electromechanics; industrialization; innovations; mechanical engineering; production processes

**Introduction.**

The electrification of the Kharkiv Plant of the Joint Stock Company (JSC) Russian Locomotive-building and Mechanical Society (RLMS), better known as the Kharkov Locomotive-building Plant (KhLP), was a significant event for the entire Russian Empire, since it became the first enterprise in the country, where to drive all production mechanisms were carried out exclusively with the help of electricity (The State Archive of Kharkiv Region [SAKhR], 1897a). Certainly, not all equipment used at the plant was equipped with an individual electric drive, which, in fact, is mandatory in today's perception of the electrification of production. However, in the era under consideration in Russia, even the replacement of steam engines on the drives of overhead transmissions of workshops with electric motors was already considered a significant step towards the electrification of production processes and, moreover, the most cost-effective step (Livshic, 1929). Thus, KhLP, at the time of its commissioning in 1897, was the most electrified enterprise in the country according to the ideas that existed at that time about economically viable methods of electrification, which makes it very interesting to study ways to achieve this result. Despite such a significant role of KhLP in the electrification of the industry of Tsarist Russia, and then – Soviet Ukraine and the Soviet Union as a whole, historians have considered the issue of the origin of this process at the plant under research itself superficially, although quite a lot of scientific works devoted to the study of the history of this enterprise have been published. So, in the article Background of creation, further development, and establishment of Kharkiv Locomotive Plant, the authors outline those organizational, financial, construction, social, personnel and design problems that JSC RLMS had to face during the construction and commissioning of the plant in Kharkov, however the moment of electrification of this enterprise was completely missed (Strelko,
Research methods.

In preparing the article, the following methods like: problem-chronological, retrospective, dia- and synchronic methods, as well as the periodization have been used. On the basis of the diachronic method, the dynamics of external factors influencing the nature of the production processes electrification carried out at KhLP have been monitored, and the synchronic method has been used in the static positioning of these factors among themselves. The periodization method made it possible to single out the individual stages of the electrification process of an enterprise during its creation, and the problem-chronological method has been used to sequentially study
each of these stages in the entire complex of profile problems being solved. The retrospective method made it possible, on the basis of the principles of historicism, to restore the scientific and technical-technological level of approaches to solving the problems of electrification of machine-building enterprises used in organizing this process in the study period. As a result of the application of this methodological apparatus, a real historical picture of the organization of the preparation of the process of electrification of the KhLP at the stage of creating an enterprise has been drawn up, which meets the principles of historicism and objectivity.

**Results.**

When planning activities for the creation of KhLP, the problem of the formation of its fixed assets by the Board of JSC RLMS was divided into three tasks: 1) design and construction of buildings and structures; 2) calculation of the necessary production equipment, auxiliary machines and mechanisms, and their arrangement of the plant; 3) design and equipping of the electric power supply system of the enterprise (SAKhR, 1895a). The organization of the solution of the last of them was entrusted to a member of the Board of JSC RLMS, mining engineer Nikolai Nikolayevich Koksharov [1857–1941] (SAKhR, 1895a). On his initiative, in November 1895, the Board involved in the development of technical specifications for the electrical-energy equipment of the KhLP: a lecturer of electrical engineering at the St. Petersburg Nikolaev Military Engineering Academy and the Electrotechnical Institute, a consultant of the Main Engineering Directorate of the Military Ministry, engineer-captain Ludomir Vatslavovich Sventorzhetsky [1865–1925?] (Fig. 1) and lecturer of the St. Petersburg Institute of Technology Alexander Aleksandrovich Voronov [1861–1938] (SAKhR, 1895b).

![Figure 1. Ludomir-Mikhail-Octavian Vatslavovich Sventorzhetsky.](image)

Meanwhile, already in December 1895, the director of the plant, Pavel Pavlovich Rizzoni [1857–1937], understood the need for constant expert-consulting support for the process of electrification of the enterprise for the entire period of its construction, about which he notified the Board of JSC RLMS. Members of the Board unanimously supported P. P. Rizzoni, approving as such a consultant with a salary of 150 rubles monthly L. V. Sventorzhetsky (Fig. 1) and with enrolling him in the service of the
RLMS from the time when he actually began to cooperate with the JSC, that is, from November 15, 1895 (SAKhR, 1896a).

An analysis of the preparatory steps taken by the Board of JSC RLMS to organize the electrification of its Kharkiv plant makes us pay attention to the fact that they initially did not consider any other options for the energy supply of KhLP, except as for exclusively electricity, what in the chronological period we are considering was atypical for the industrial sector Russian Empire. The most common in the country at the end of the nineteenth century the power supply scheme for the production equipment of machine-building plants was the transfer of mechanical energy to it through belt (and in some cases – chain) drives from transmissions located under the ceilings of workshops. The latter, in turn, were mechanically connected to gearboxes driven by steam engines, which had different combinations of placement: from one per shop to one for each overhead transmission – depending on the absolute value of the power consumption of the entire shop, as well as on the type of steam engine used (piston or turbine). Electricity at such enterprises, according to, for example, L. Davydova, was used only for lighting, although we cannot exclude cases of using electricity to drive industrial equipment, but these cases, if they did occur, were definitely isolated (Davydova, 1966). This statement is based on the fact that in the considered scheme of combined electric and steam power supply of machine-building enterprises, block-stations were used as electric generating plants. The principle of their design was that the electric power supply to the corresponding equipment was supplied from batteries charged by a generator connected to an external or internal combustion engine, which, in view of the low productivity of such systems due to the then imperfection of batteries, a priori excluded the possibility of connecting to them, along with lighting, any-more power electrical force devices. To the above, it can be added that if there are still references to the use of block stations for arranging factory lighting in historical literature or documents, then no information has yet been found about the use of these stations as power sources for power equipment, which, in fact, confirms the imperative stated earlier about the objective conditionality of the singularity of such cases at the machine-building enterprises of the Russian Empire in the era under study (Orlov & Budagov, 1894; Suvorin, 1895; Annienkov, 2014).

A less common, but actively gaining popularity in the second half of the 1890s [especially in the Ukrainian provinces of the Russian Empire], the power supply scheme for new metalworking plants was a combination of the use of steam engines and factory power plants. The high productivity of the latter [compared to block stations] made it possible to significantly electrify production processes, which, however, was limited by technological energy intensity, such as, for example, inherent in metallurgical operations. This restriction was caused by the imperfection of the “protectionism policy” pursued by the tsarist government, resulting in a very high price for practically not manufactured in the country and imported from abroad: both used directly by the siderurgy and in the electric power industry large electric machines [such as, for example, presented on fig. 2], made their use much less cost-effective than
the use of special steam engines (Alexandrov et al., 1957). Therefore, large-scale engineering plants, in production processes in which a large share was occupied by the manufacture of bulky and heavy metal blanks, as well as giant metallurgical plants, which have large repair and machine-building workshops, provided the electric power only metal-cutting and mechanical assembly equipment. Among such enterprises founded at the same time as KhLP, metallurgical plants can be attributed: the Belgian JSC Iron-rolling plant in Konstantinovka [1896], the Donetsk-Yuryevsk metallurgical JSC in Alchevsk [1895], the Nikopol-Mariupol mining and metallurgical JSC in Sartana [1896], Russian-Belgian metallurgical JSC in Enakievo [1897], as well as the Kramatorsk machine-building plant [1899], the Naval machine- and shipbuilding plant in Mykolaiv [1895]; locomotive-building plant Hartmann in Lugansk [1896] (Ministry of Finance & Ministry of Trade and Industry of the Russian Empire, 1911).

Figure 2. Electric power equipment consisting steam turbines geared to direct current generators 250V/5MW made by General Electric Company and which provided to Russian Empire at the end of the 19th – begin 20th century. (SAKhR, 1916).

Therefore, based on the situation described above, and also taking into account the type of the main product of the enterprise under study, we come to the conclusion that, when deciding on the full electrification of all production processes at the KhLP, the Board of JSC RLMS in advance intended to receive the large metal blanks necessary for the plant from outside. This is confirmed by the fact that even before the start of the construction of the plant, the Chairman of the Board of JSC RLMS entered into relations with the Boards of steel and copper rolling enterprises to discuss the possibility of concluding long-term contracts with them for the supply to KhLP of large-sized: steel casting, steel and copper rolled products, forgings (SAKhR, 1895c). This approach of exclusion from the technological chain of operations for casting and plastic deformation of massive blanks made it possible to carry out a complete electrification of production processes at KhLP without the need to purchase expensive electric drives for the corresponding equipment, what, however, it was not the know-
how of JSC RLMS, since in the 1890s it was already widely used in American mechanical engineering and begin mastered by European mechanical engineering (Atmakin, 1936). At least one of the co-founders of JSC RLMS, Philippe Bouheu [1836–1899], co-owner of the machine tool plant in Montzeron [France] that he and his brother Étienne inherited from his father, actively studied this American practice and applied it both at the specified plant, and at other enterprises created by the brothers in 1895 Société Française des Corps Creux in Montbard [France] (Morvan, 2023). So, there is every reason to believe that the method of placing orders for large: rolled products, forgings and castings at specialized factories, instead of being manufactured by machine-building enterprises on their own, was brought to the Russian Empire by Ph. Bouheu, as one of the directors of the Board of JSC RLMS. However, this method was approved for use only according to the conclusions from the excursion trip of P. P. Rizzoni 14–31 August 1895 in the engineering factories of France, during which he together Ph. Bouheu visited both the Bouheu brother’s plants and other engineering factories, including plant of the Société Alsacienne de Constructions Mécaniques in Belfort (SAKhR, 1895d).

Meanwhile, the director of the Société Alsacienne de Constructions Mécaniques was Alfred George de Glehn [1848–1936], one of the most famous steam locomotive designer in Europe at the time\(^1\), under whose leadership in Europe at 1895 were built already three successfully operating locomotive-building plants according to the same scheme for organizing the production process, according to which KhLP was later built (SAKhR, 1895d; The Times, 1936). Thus, as we can reasonably assume, the final decision on the full electrification of the JSC RLMS plant in Kharkov was made by the Board of the Company only after P. P. Rizzoni, who’s delegated by it to assess the possibility of the effective functioning of the enterprise on the accompanying such electrification of the scheme for organizing production processes in the conditions existing in the Russian Empire, confirmed this. At the same time, attention is drawn to the fact that even before the specified trip abroad P. P. Rizzoni, and three and a half months before A. A. Voronov and L. V. Sventorzhetsky were attracted as experts [that is, before the official final approval of the decision on the full electrification of the KhLP], the representative office of Siemens & Halske in St. Petersburg has already sent to the Board of the RLMS a proposal (fig. 3) for its services in drawing up a project for the electrification of the plant (SAKhR, 1895e).

All other firms specializing in the Russian Empire in the electrification of industrial facilities: both with their own produced electrical equipment, and on the basis of purchased electrical equipment or in a mixed scheme, turned to JSC RLMS with similar proposals much later. So, for example, a representative of the Swiss electrical engineering concern Brown-Bowery submitted a corresponding proposal in October 1895, and representatives of the specialized Kyiv technical office of the Henry Smith

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1 His father was a nobleman of Prussian origin, who moved from near Tallinn (Estland province of the Russian Empire) to England, therefore, in the documents of the Russian Empire, the spelling of the surname “de Glehn” in its German transcription may be found: “von Glehen” or “de Glehen”].
& Co Trading House – at the end of November of the same year (SAKhR: 1895a, 1895f).

Figure 3. Letter of offer from Siemens & Halske for the provision of their services in the design of the electrification of KhLP, dated July 24, 1895 (SAKhR, 1895e).

However, on October 19, 1895 [one and a half months before the announcement of the tender for the KhLP electrification project], the Siemens & Halske representative already submitted a preliminary estimate for the plant's electrification, which could not be done without at least a preliminary corresponding design, which, in turn, also it would be impossible to draw up without having at least a master plan for an enterprise under construction with the power parameters of the equipment intended for use displayed in it (SAKhR, 1895g). By the way, chronologically, this event almost coincides with the refusal of Usines Bouheu to fulfill its shareholder contractual obligations regarding the provision of a detailed project for the construction of the KhLP, which occurred after the board of JSC RLMS received from it the master plan of the plant and before it was supposed to receive detailed design [before October 13, 1895] (SAKhR, 1895a). The mentioned refusal was never officially announced by Usines Bouheu and was realized by a simple failure by her to fulfill her obligations, which led to the need to hire the architect Alexander Ivanovich von Goghen [1856–1914] by the JSC RLMS, and subsequently made it possible for the Board of the JSC
to accuse Usines Bouheu of sabotage KhLP design work (SAKhR, 1896a). However, it should be noted that this accusation did not receive any legal formalization, whereas, for example, Usines Bouheu’s untimely fulfillment of its shareholder obligations to supply KhLP with production equipment ended with the filing of financial claims against this company by JSC RLMS, which, after settlement of the issue of their magnitude, were recognized and satisfied by the Usines Bouheu (SAKhR, 1897b). That is, the failure to provide Usines Bouheu with a detailed KhLP project, apparently, did have reasons, however for the legal justification of which Usines Bouheu, most likely, did not have documented facts, and that did not lead to the official registration its refusal to fulfillment of its shareholder contractual obligations in this part. At the same time, these reasons, as we can assume, were of a discrediting nature for certain influential members of the Board of JSC RLMS, leading, if they were made public, to certain reputational losses of the Company even without documented facts, but only on the basis of a logical comparison of the showed results of the relevant events, which and became an obstacle for JSC RLMS to file appropriate financial and legal claims against Usines Bouheu.

In any case, the fact of leakage of information about the plans for electrification of the plant of JSC RLMS planned for construction in Kharkiv committed by the Board of this Society is obvious, as is the fact that the largest volumes of this kind of information were received by the St. Petersburg representative office of Siemens & Halske. This is what allowed Siemens & Halske to prepare more thoroughly than all other future bidders for the electrification of KhLP to prepare for the competition of projects, among other things, by initiated the use of a direct type of electric current at the plant, the advantages of which it was detailed by the company’s engineers in the previously mentioned estimate of the electrification project enterprises dated October 19, 1895 (SAKhR, 1895g). In fact, all these arguments were used by A. A. Voronov, L.V. Sventorzhetsky and P. P. Rizzoni when they drew up the terms of reference for the electrification of the plant in November 1895, and if they were not quoted, then at least they were repeated very close to the text of the explanations of the Siemens & Halske engineers (SAKhR: 1895g, 1895h). However, otherwise, the specified terms of reference differed significantly from the method of electrification of the KhLP proposed by Siemens & Halske, primarily because of the chosen by A. A. Voronov, L. V. Sventorzhetsky and P. P. Rizzoni power generation scheme. So, Siemens & Halske proceeded from the need to use 6 dynamos with a total capacity of 1,250 hp, of which one machine in 250 hp had to work exclusively for lighting, while the specialists of JSC RLMS considered 3 dynamos with a total capacity sufficient of 900 hp, powering the lighting according to the traditional scheme — from a battery block-station charged by one of the total numbers of installed generators at a time when production processes at the plant were not carried out (SAKhR: 1895g, 1895h, 1895j).

The effectiveness of the proposed A. A. Voronov, L. V. Sventorzhetsky and P. P. Rizzoni plant power supply scheme requires additional historical research aimed at studying the economic efficiency of the use of battery block-stations in the era under
consideration in the Russian Empire in general and in its Ukrainian territories in particular. The absence of such studies greatly complicates the possibility of an objective technical and economic assessment of the option developed by these specialists for organizing the electric power supply of KhLP. However, it was in the economic context that the relevant terms of reference were studied by N. N. Koksharov, which, based on his approval of this option, as well as the information we have about the planned exclusively single-shift operation of the plant, allows us to assume it’s then economic feasibility, unless, of course, we take into account the possible prospect of the plant switching to a multi-shift operation (SAKhR, 1895k). To the above, it should also be added that the current economic aspects in a whole influenced the preparation of the terms of reference for the electrification of the KhLP by the specialists of JSC RLMS more than the technical nuances that determine the prospective economic efficiency of the planned measures for the electrification of the enterprise. So, for example, when choosing the type of electric current used, as mentioned earlier, the arguments of Siemens & Halske engineers were used, based on the fact that current transportation within the enterprise will not cause a significant reduction in the efficiency of the power grid as a whole due to losses in her energy in the case of choosing direct current. However, it should be noted that this argument is unequivocally fair: 1) only when comparing the efficiency of the power supply network and the efficiency of the shafting network of the corresponding mechanical transmissions, and not the efficiency of the DC network and the efficiency of the network AC current; 2) on the condition that the power grid will not grow further due to the expansion of the plant, – and this was definitely known to such qualified specialists as A. A. Voronov and L. V. Sventorzhetsky, who's nevertheless supported this argument. At the same time, both them and P. P. Rizzoni, and N. N. Koksharov mentioned the technical side of the issue of choosing the type of current as if in passing, but the cheapness of complete electrical equipment operating on direct current compared to the same, but operating on alternating current, is considered in more detail, by the way, as well as by Siemens & Halske engineers (SAKhR: 1895g, 1895h, 1895k).

Meanwhile, the interest of Siemens & Halske specialists in focusing the issue of choosing the type of current on the cheapness of equipment is entirely understandable, since during the study period, two electrical companies, Westinghouse and Allgemeine Elektricitäts Gesellschaft [AEG], had patent priority for the manufacture of equipment operating on alternating current, although it was disputed by them between yourself (Anienkov, 2020). Therefore, by offering AC electrification at KhLP, Siemens & Halske a priori weakened their competitive position if Westinghouse and AEG were involved in the tender for this event. Although it should be recognized that the arguments of Siemens & Halske regarding the need to install additional transformer equipment when choosing an alternating current electrification scheme, which inevitably increases the cost of this project, are absolutely true, but do not take into account the fairly fast payback rates of the corresponding costs. In turn, the specialists of JSC RLMS also had a reason to lean towards choosing a direct current, since,
according to the agreement between the shareholders of JSC RLMS, part of the authorized capital of the Company, attributable to Ph. & É Bouheu, were supposed to compile, among other things, the necessary KhLP metal-cutting machines with an individual electric drive and electric overhead cranes manufactured by Usines Bouheu and consuming direct current (Anniyenkov, 2014). That is, approximately 20% of the production equipment planned for operation at the KhLP (and de facto purchased) was already focused on the use of direct current even before the development of the technical assignment for the electrification of the plant.

Figure 4. Letter from Maschinenbau Schwartzkopf to the Board of JSC RPMO regarding its participation in the tender for the electrification of KhLP (SAKhR, 1895l).

Thus, according to the coincidence of opinions of the members of the Board of JSC RLMS, the director of KhLP and electrical experts, it was decided to use direct current at the enterprise, which formed the basis of the technical specifications for the project for the electrification of the plant, for which, at the insistence of N. N. Koksharov and L. V. Sventorzhetsky, only five European electrical companies that had a high reputation and guaranteed not only high-quality, but also fast execution of work were admitted – Oerlikon [Switzerland]; Siemens & Halske, AEG, Lahmeyer [all three from Germany]; Hillairet [France] (SAKhR, 1895b). However, an analysis of the correspondence of JSC RLMS with foreign companies shows that, despite the official decision of the Board, the notice of this tender was sent not only to these
companies. So, for example, the German *Maschinenbau Schwartzkopf*, which owns both a steam locomotive plant in Germany similar in terms of production scheme and productivity to *KhLP*, and an electrical factory that produces the entire set of electric machines and equipment necessary for the electrification of such enterprises, also was receive notification of this tender, and simultaneously with the technical task for the relevant project and with notification of her non-participation in the competition, and just a week before it was supposed to take place. At least, this follows from the response letter from *Maschinenbau Schwartzkopf* to the Board of JSC *RLMS* (fig. 4), although such facts are not reflected in the minutes of the meetings of the Board of the Company (SAKhR, 18951). This fact, as well as the refusal of JSC *RLMS* from the plan initially approved by its Board to take as the basis for the electrification scheme of *KhLP* the corresponding schemes already in use at enterprises similar to this plant, *Société Française des Corps Creux* or *Société Alsacienne de Constructions Mécaniques*, gives reason to believe that until the very end of the process of preparing for the tender for the electrification of *KhLP*, the Board of JSC *RLMS* was unanimous only in its opinion regarding the full electrification of the plant, but the ways of its implementation among the members of the Board caused disagreement. The essence of these disagreements lay in the plane of choice between the power supply of the electrical systems of enterprises, already dominant in Europe, exclusively directly from electric generators, and the power supply of factory power networks from battery block stations, which prevails in the Russian Empire.

The first option did not raise doubts about its effectiveness among Russian electrical engineering specialists, however, the lack of experience in its application in the country caused a certain wariness among the co-founders of JSC *RLMS*, who were far from the technical side – representatives of banking capital, who were more inclined towards the tried and tested second. Therefore, the proposed A. A. Voronov’s and L. V. Sventorzhetsky’s version of the *KhLP* combined electrification scheme became, in fact, a compromise from a technical point of view, but hardly the cheapest - from a financial point, since it required both a special project and an individual set of equipment, which, moreover, could only be provided by electrical engineering firms at the same time with strong research and production bases. At the same time, the use of ready-made standard projects and sets of electrical equipment for them, without a doubt, is a cheaper way of electrification, which could be organized by less powerful electrical companies, and even electrical divisions of similar to Kharkov’s machine-building plant, that we studding, – based on the projects they have already acquired for own electrification and their experience in the purchase, installation and operation of the corresponding complete equipment. That is, considering the preparation for the tender for the electrification of *KhLP* through the prism of different positions of the founders of JSC *RPMO* on the financial side of this issue\(^2\), previous example of

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\(^2\) *Although not reflected in the documents of the Board, but objectively taking place due to the investment essence of the project of creating the Company as a whole: by combining a private capital of the banking and industrial sectors of the economy, as well as attracting personal financial resources of major government officials.*
Maschinenbau Schwartzkopf is not an incidental case, but was the result of attempts by certain circles in the Board of JSC RLMS to find a cheaper and at the same time more technically effective than proposed by A. A. Voronov and L. V. Sventorzhetsky, the option of electrifying his plant so that the interest of all the founders of the Society in it would allow revising the results of the competition even if such a project would be presented after it was held.

Meanwhile, all sorts of attempts to reach a financial compromise in the decision regarding the electrification of KhLP, carried out bypassing the technical compromise, were initially doomed to failure, because, as mentioned earlier, a sharp transition to full electrification of production according to the Western model in Russia at the end of the 19th century considered to be an excessively risky financial undertaking. And the basis for the formation of its opinion was not only the lack of experience in operating such systems, but also the complete absence of any current policy in the field of electrification of the country, or at least a vision of the foundations of such a policy in the future at the level of state management institutions, which forced financial circles of the empire to be very wary of the relevant investments of capital. Thus, the need to reach a compromise in the technical scheme for the electrification of KhLP, as a palliative, allowing, on the one hand, to avoid the possible, due to the long-term uncertainty of the object of financing, a departure from the latest concept of full electrification of the plant to partial electrification, which has already become normal practice in Russia\(^3\), and on the other hand, to preserve the possibility of a subsequent rapid transition to the Western model of electrification, was indisputable for all technically competent founders of JSC RLMS or their representatives on the Board. This, taking into account the low awareness of electrical engineering issues that existed then in the Russian Empire, even among the technical intelligentsia, as well as the level of the task being solved, which is quite difficult for a qualified assessment, made it possible to avoid significant influence of other points of view on organizing and conducting a competition for the electrification of KhLP, except as technically competent. That is, the organizers of this tender managed to exclude the possibility of consideration by the Board of JSC RLMS of any other projects except for the five firms officially admitted to the tender, despite the fact that, as the chronology of the relevant correspondence of JSC RLMS with other companies shows, attempts to start the course of events in a different way were made. However, only three companies: Oerlikon, Siemens & Halske and AEG, took full part in the competition, providing both detailed designs and reasonable cost estimates for products, materials and works. Although, it must be admitted that the preparation time for the competition was very short (one month), as a result of which costs estimates for the electrification of KhLP presented by Lahmeyer and Hillairet turned out to be incomplete, and Hillairet's project, moreover, turned out to be completed only in general terms (SAKhR: 1895m, 1896a). That is, initially only Siemens & Halske, which received information on the planned

\(^3\) Which was mentioned at the beginning of the article.
The electrification of the JSC RLMS plant in Kharkiv long before the announcement of the competition in volumes sufficient to draw up the relevant preliminary design and estimates, had a guaranteed opportunity to provide design and estimate documentation of the required completeness within the deadlines established by the competition and quality. To do this, she only had to make changes according to the terms of reference of JSC RLMS in the existing calculations, and not start the design again, like all the other electrical companies participating in the tender.

In other words, the fact that Oerlikon and AEG, which are in much worse conditions than Siemens & Halske, nevertheless managed to properly prepare for the tender for the electrification of KhLP, indicates the high scientific and technical potential of these two companies, however, which was ignored by the Board of JSC RLMS during the competition itself. Thus, we have every reason to believe that not only the preparation for tender, but also the tender for the electrification of KhLP itself was held by the Board of JSC RLMS somewhat biased in favor of Siemens & Halske. So, for example, the total cost of electrification of the plant, proposed by Oerlikon, was only 1% higher than the cost proposed by Siemens & Halske [tab. 1], however, Oerlikon guaranteed the efficiency of the entire system of 75.27% versus 74% for Siemens & Halske (SAKhR, 1896c). That is, in case of winning the Oerlikon tender, having paid money to this company 1% more than Siemens & Halske disposably, JSC RLMS received 1.27% more useful capacity on the entire life of the KhLP electric power system. Nonetheless, the contract with Oerlikon was recognized as unprofitable, since, according to the conclusion of L. V. Sventorzhetsky in the project of this company, the efficiency loss in electrical wiring was 9% versus 3% for Siemens & Halske, and the overall high efficiency was achieved due to the high efficiency of the electric machines used (SAKhR, 1896d). Meanwhile, from an economic point of view, to assess the profitability of operating a production power supply system, its overall efficiency is important, and not its discrete value for individual elements of this system. Although, of course, from the technical side, the lower efficiency of the conductive elements in the KhLP electrification project presented by Oerlikon made it problematic a possible future increase in the power supply capacity of the plant on the existing electrical wiring due to a progressive drop in efficiency in this case, or even physical its inability to bear the applied load at a whole. However, on the other hand, AEG's proposal, based on the preventive power reserve of the enterprise's power supply system [as we see in tab. 1], also did not find support from the Board of JSC RLMS, despite the fact that, in terms of a unit of capacity, the total cost of electrification of KhLP, proposed by AEG, amounted to 149 rubles. 68 kops. for 1 hp against 152 rubles. 78 kops. for 1 hp from Siemens & Halske [or 2% less]. That is, the management of JSC RLMS during the tender did not take into account [or took into account selectively] a possible increase in electricity consumption by its plant in the medium term, which makes the feasibility study of Oerlikon's refusal to electrify KhLP very doubtful.
### Table 1. Key indicators of cost estimates for *KhLP* electrification projects presented by competing firms [compiled according to: (SAKhR: 1896b, 1896c)].

<table>
<thead>
<tr>
<th>Name of the firm-contractor</th>
<th>Power of an electric station (hp)</th>
<th>Total cost of electrification of <em>KhLP</em> (rub.)</th>
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<td>Originally stated</td>
<td>Changed during the competition</td>
</tr>
<tr>
<td><strong>Hillairet</strong></td>
<td>900</td>
<td>94 726,00</td>
<td>94 726,00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The project is presented only in general terms; the estimate is given without taking into account the cost of delivery of components and their installation</td>
<td></td>
</tr>
<tr>
<td><strong>AEG</strong></td>
<td>1 200</td>
<td>197 856,04</td>
<td>179 610,00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the project, instead of generators with a total capacity of 900 hp, generators with a total capacity of 1,200 hp are included, and the cross-sections of the wires of the power grid are not indicated.</td>
<td></td>
</tr>
<tr>
<td><strong>Siemens &amp; Halske</strong></td>
<td>900</td>
<td>154 730,00</td>
<td>137 500,00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Without comments</td>
<td></td>
</tr>
<tr>
<td><strong>Oerlikon</strong></td>
<td>900</td>
<td>138 874,00</td>
<td>138 874,00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Project and estimate are not detailed enough</td>
<td></td>
</tr>
<tr>
<td><strong>Lahmeyer</strong></td>
<td>900</td>
<td>132 054,00</td>
<td>132 054,00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The estimate does not take into account materials that the company was supposed to purchase in Russia</td>
<td></td>
</tr>
</tbody>
</table>

Moreover, a similar refusal to *AEG* is also puzzling, since just replacing the power generating unit proposed by this company with a unit of the same capacity as that of *Siemens & Halske* or *Oerlikon* could reduce the final cost of electrification of *KhLP* under the *AEG* project at least to the cost proposed by *Siemens & Halske*, with
an efficiency equal to the guaranteed Oerlikon and keeping of electrical wiring, allowed without any significant loss in it, the efficiency of the system as a whole, if necessary, to increase the power of the latter by a third. In spite of all the above, the Board of JSC RLMS did not proposed AEG to revise its project in the direction of reducing the power generating unit, which, in principle, would not have taken many times for the company's engineers, given that they completed the full project in month. Moreover, the design competition was held on January 19, 1896, when the snowy and frosty winter in Kharkov forced the suspension of all construction work at the KhLP until the end of April of this year, and the design of the power station by the architect of the plant A.I. von Goghen was carried out almost last, which, however, was due to the objective necessity of the initial design of production areas (SAKhR: 1896e, 1896f).

Thus, there is every reason to believe that the victory of Siemens & Halske in the tender for the electrification of KhLP was not due to the technical and economic advantages of the corresponding project presented by this company over the projects of its competitors, although its high scientific and technical level cannot be denied. The presence of other reasons for this victory allows us to consider both the previously indicated facts regarding the leakage of confidential profile information from the Board of JSC RLMS in favor of Siemens & Halske, and the fact sanctioned by the Board a personal meeting of its Chairman Viktor Mikhailovich Ivanov (1846–1919) with a representative of Siemens & Halske in St. Petersburg, which took place approximately 10 days before the tender, at which, as follows from the minutes of the Board meeting, there was a discussion about reducing the originally announced by Siemens & Halske cost of electrification of KhLP (SAKhR, 1896b). It is embarrassing as that the meeting was initiated by this representative, both that all such discussions with representatives of other firms participating in the competition were carried out by correspondence. Personal meetings on business matters with the management of the Board of JSC RLMS were not initiated either by the Board itself or by other competing companies, despite the presence of their authorized representative offices in St. Petersburg [at least, there are no corresponding mentions in the documents of JSC RLMS]. This exclusion in relations with the contestants, made for Siemens & Halske, chronologically coincides with the beginning of preparations for the creation of JSC Russian Electrotechnical Plants Siemens & Halske [Highly approved in 1898] with the proposed construction of a parent enterprise in St. Petersburg and a network of small electrical plants , the geographical location of which was to correspond as closely as possible to the centers of the areas of greatest consumption of Siemens Corporation products and services. The rest of the tender participants, at the time of its holding, did not raise the issue of creating their own plants on the territory of the Russian Empire, while the plant of another division of Siemens Corporation – Siemens-Schuckertwerke had been operating in St. Petersburg already for more than 40 years, which made intentions in 1895 regarding the creation of the above joint-stock company entirely real. Taking into account the “protectionist policy” being pursued by the tsarist government at the same time, as well as the fact that high-ranking government officials were present among the
leadership of the Board of the JSC **RLMS** [such as, for example, an official for special assignments under the Minister of the Imperial Court N. N. Koksharov was one of the directors of the Management Board and General V.M. Ivanov was its Chairman], and the fact that both profile experts of JSC **RLMS**: and A. A. Voronov, and L. V. Sventorzhetsky were real state servants [and the latter, moreover, an officer], we get a reason to make an assumption about a more meaningful conversation between the Chairman of the Board of JSC **RLMS** and a representative of **Siemens & Halske** than was displayed in the minutes, and which was carried out taking into account the state interests of the Russian Empire. And the incompleteness of information about it in the protocol wording, in this case, may well be due to the need to keep the competitive secret of its counterparties, especially since the process of creating **Siemens & Halske Russian Electrotechnical Plants** JSC at the time of the tender was in the phase when the corresponding the decision by the management of **Siemens Corporation** had already been made, but its implementation is still being prepared.

![Image](https://www.hst-journal.com)

**Figure 5.** Siemens N-type electric motors with power from 1 hp to 60.5 hp, installed since 1896 for metal-cutting machines manufactured by KhLP (SAKhR, 1896k).

That is, we can say that the victory of **Siemens & Halske** in the tender for the electrification of **KhLP**, with rather dubious technical and economic advantages of the project presented by it, could with a high degree of probability be the result of strategic agreements between this company and JSC **RLMS** about the further cooperation in context of the “protectionism policy” pursued in the country, what kept secret from **Siemens**’s competitors. We find indirect confirmation of this in almost simultaneously with this victory [a month later] the emergence in JSC RPMO of a project to organize a joint production of electric locomotives with **Siemens & Halske** at the same **KhLP**, however, not implemented both due to a lack of free production capacities at the plant, and because of the small current demand for them in the domestic market of the empire (SAKhR, 1896g). However, the fact that this project of the AO **RLMS** was considered
seriously is evidenced by the fact that from May 1896 L. V. Sventorzhetsky as Society's expert had on a three-month trip abroad in order to get acquainted with the practice of electric locomotive construction at foreign electrical plants (SAKhR, 1896h). Also, an indirect confirmation of the existence of strategic agreements on further cooperation between Siemens & Halske and JSC RLMS even before the tender for the electrification of the KhLP was held is that, starting from December 1, 1896 [that is, even before the completion constructing works on the plant] machine tools according to the drawings of Usines Bouheu, those that manufactured with an individual electric drive, was equipped with electrical equipment exclusively by Siemens & Halske, and not by specified in the original technical documentation - for the most part by French electrical companies (SAKhR: 1896j, 1897c). At the same time, the discount in the price for this electrical equipment, provided by Siemens & Halske to JSC RLMS, ranged from 15% to 20% of its minimum price in free sale on the domestic market of the Russian Empire (SAKhR, 1897c).

Discussion.

The statements given in the presented material are largely based on assumptions, which is due both to the small number of documents that have survived today in Ukraine regarding the issue under consideration, and the practice of verbal agreements inherent in business on the most confidential aspects of partnerships. However, all the assumptions are made on the basis of the imperatives of the theory and practice of mechanical engineering technology, as well as the theoretical foundations of electrical engineering, applied in accordance with the principles of historicism, which allows us to consider the presented historical picture of the organization of the preparation of the KhLP electrification process at the stage of creating the plant as an objective picture at a whole. At the same time, the authors admit the possibility of further identification of additional historical facts that specify the role of individual individuals or legal entities in solving the issue considered in this article – both already known and newly established. Also, taking into account the volume and geography of the corresponding correspondence of the JSC RLMS, the authors do not exclude the entry into scientific circulation of new documents on the topic they studied. However, the probability that the information contained in these documents in its general meaning will contradict the already established one remains extremely low, if only because of the limits of the semantic variability of the information necessary for JSC RLMS on the organizational preparation of the KhLP electrification process, which have already been finally clarified, and examples filling in the information field in which are already given.

Conclusions.

The electrification of the KhLP became a significant event that determined the further path of development of the industry not only in the Ukrainian territories of Tsarist Russia, and not only in the empire as a whole, but also in Ukraine and the Soviet Union, because that choice of the scheme for organizing production processes, which
was made due to objective and subjective circumstances in its implementation has been made for the first time within the territorial boundaries under consideration, and subsequently was used massively and constantly [albeit with varying degrees of success], despite the changes in socio-economic relations and political-social structures that took place within them. Thus, the experience of electrification of the KhLP is successful, which, considering it as a major innovative event, allows us to once again be convinced of the unambiguous effectiveness of such events only when they are carried out simultaneously with the introduction of a set of other innovations that make it possible to use the most of the advantages to be acquired. At the same time, the organizational preparation for the electrification of KhLP had certain nuances that led to both positive and negative consequences for the further operation of the enterprise, including in terms of establishing the practice of making compromise decisions by the relevant management on issues that were controversial only due to technical incompetence leading staff. Thus, due to lobbying by one part of the Board members of the JSC RLMS of the interests of only one participant in the tender for the electrification of KhLP – Siemens & Halske and the technical incompetence of its other part, the applied electrification scheme of the enterprise under study turned out to be not the cheapest in execution and obsolete already at the time implementation, which later led to its radical alteration at an already operating plant. However, on the other hand, cooperation between JSC RLMS and Siemens & Halske has become one of the factors contributing to the development of the electrical industry in the country, moreover, on the basis of scientific and technical experience and material resources of one of the world's best manufacturers of electrical equipment. In addition, this manifestation of the “protectionist policy” served as one of the brightest examples for other leading world manufacturers of electrical engineering in terms of demonstrating the opportunities that open up for them in the market of the Russian Empire if enterprises of the corresponding profile are organized in it.

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**Conflicts of interest.**

The authors declare no conflict of interest.

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Нюанси організаційної підготовки електрифікації Харківського заводу Російського паровозобудівного і механічного товариства (1895–1896 гг.)

Анотація. Перехід до електромеханічного приводу устаткування став новою віхою в індустриалізації, що привела до значного: зростання продуктивності праці та зниження енергоспоживання виробничих процесів. Але на українських землях Російської імперії дана інновація до середини 1890-х років не впроваджувалася, і лише саме з того часу процес електрифікації виробництва на українських підприємствах отримав свій розвиток, проте при цьому на них зберігався й паромеханічний привод обладнання. Харківський завод Акціонерного товариства «Російське паровозобудівне і механічне товариство» став першим підприємством не лише в українських губерніях Російської імперії, але й у всій країні, на якому було застосовано виключно електромеханічний привод усього устаткування. Зважаючи на даний пріоритет, організаційна підготовка процесу електрифікації цього підприємства також стала першими у країні досвідом впровадження такої інновації, порівняно іноді лише з досвідом переходу від механічного на паромеханічний привод, який, однак, у Російській імперії був досліджений. При цьому, рівень технічної компетенції частини керівництва Акціонерного товариства «Російське паровозобудівне і механічне товариство» був недостатньо високим для того, щоб надавати adekvatnu tehniko-ekonomichnu otsinku vidpovidenim innovatsijam. Через це організаційна підготовка електрифікації Харківського заводу означеної Товариства проводилася без яких-небудь чітких методологічних підходів, яка у дискусії щодо
схеми електрифікації підприємства привела до заміни питання вибору оптимального варіанту з ефективних питанням вибору оптимального з дешевих. В результаті, експертами Товариства було розроблено технічне завдання на компромісний варіант проекту електрифікації, суть якого полягала у встановленні відносно нового за технічним рівнем електрообладнання, що експлуатувався по вже застарілій схемі, це робило даний варіант електрифікації ані ефективним ані дешевим, але політично проблемним для усього керівництва Товариства. Досягти очікуваної вигоди від електрифікації заводу в результаті вдалося не від запровадження обраної схеми її проведення, а шляхом укладання стратегічних домовленостей із компанією Siemens & Halske, згідно з якими Правління Товариства забезпечило її перемогу в конкурсі на електрифікацію свого підприємства за прийнятною ціною, а Siemens & Halske, в свою чергу, в подальшому постачало свою продукцію із значними знижками.

Ключові слова: електропривод; електромеханіка; індустріалізація; інновації; машинобудування; виробничі процеси

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