Securing staff competences and know-how in the scope of maintaining the technical conditions of coal-fired units in the period prior to their replacement by RES

Ewa Trzeszczyńska, Jerzy Trzeszczyński and Radosław Stanek

In the foreseeable future, energy security in many European countries cannot be ensured without continuing to operate coal-fired power plants. This also applies to Poland, where lignite and hard coal account for approx. 60 % of electricity generation. The final phase of coal-fired power plant operation contains many unknowns. While their operating conditions will be increasingly distant from those for which they were designed, the economic effect of their operation may make it difficult to maintain their technical condition according to standards ensuring their availability required for sources stabilizing the energy system. Competence in maintaining the technical condition will be crucial to meeting these expectations. An important part of maintenance is diagnostics as a source of knowledge about the current technical condition. Modern analytical, digital and IT technologies significantly improve its capabilities. Skillfully applied algorithms can replace specialists, the lack of which is becoming increasingly visible. A tailored organization of maintenance, including diagnostic services, can significantly reduce the risks associated with the longer and more flexible operation of coal-fired power plants and entire power plants.

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Power sector in Poland – current status and an attempt at a forecast

Continuing the operation of coal-fired units, including those of the 200 MW class, still has no rational alternative. It creates hope for covering the forecasted, negative power balance in the Polish power system after 2025 and can ensure a significant increase in generation from renewable energy sources, safe for the National Energy System, at least until gas-fired units with a capacity adequate to the needs and energy storage facilities with an appropriate capacity are built. These possibilities should be created by around 2030.

The generation of electricity and heat from hard coal and lignite is systematically decreasing. Its share in the current energy mix is approx. 60 %, Figure 1. The share of energy from renewable energy sources is systematically growing, however, as Figure 2 shows, the security of the power system in Poland still depends on energy generation from coal. This will change, regardless of the pace of increase in generation from renewable energy sources, only when large-scale energy storage facilities are built and coal units are replaced by gas units, which, due to their flexible mode of operation, will have to use support on the Capacity Market or some equivalent thereof.

Each group of thermal-mechanical units/devices (Figure 1) is specific in many respects – maintenance, including diagnostics, should take this into account.

The above-mentioned units have been modernized many times in the past, especially the 200 MW class units. Some 200 MW units have an operating time similar to the supercritical units considered new. The operating time of the oldest units/devices, especially in CHP plants, is approaching approx. 350 thousand hours.

It is currently assumed that the coal-fired units will be in operation for another 10-15 years. During this period, they will be gradually decommissioned in accordance with the needs of the Operator. Technical capabilities and competences in the field of maintenance may be one of the reasons for decommissioning.

Change of the coal unit operating mode – identification of threats

The displacement of coal-fired units from the energy market by RES generation means that their operating time is systematically shortening, the number of start-ups is growing and unplanned downtimes are getting longer. This results in a faster loss of durability of some structural elements and nodes as well as worsening economic conditions of power plants operating power units in this mode. Support from the Capacity Market may not cover all units and the amount of support may not be sufficient to ensure maintenance at an appropriate level. This situation also translates into the economic condition of repair and diagnostic companies. It is one of the factors of the deteriorat-

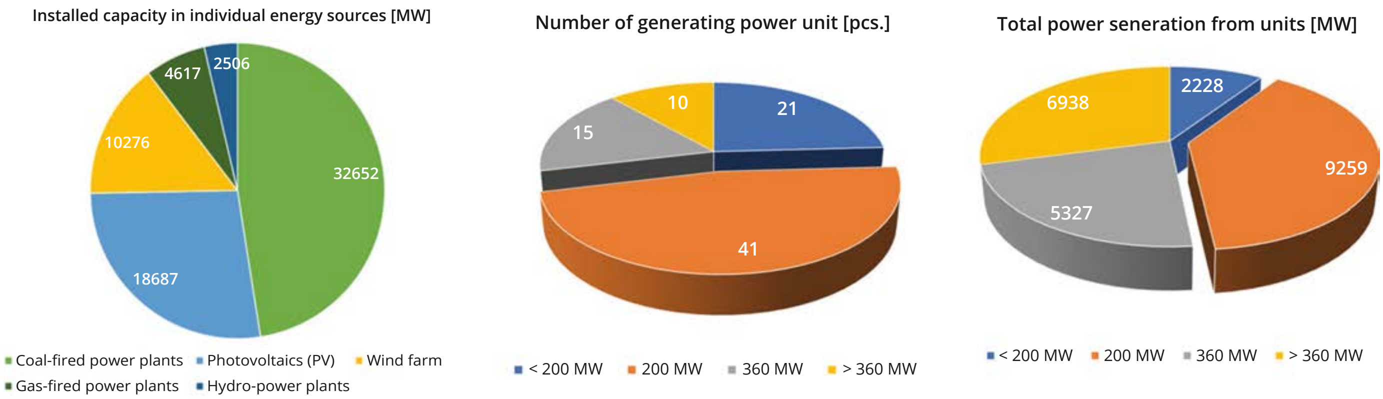

Fig. 1. Basic information on the current structure of the National Power System according to available generation sources, the number of coal-fired power units and their capacity.

DAY	18-02-2025 11:20
DEMAND [MW]	25 217
GENERATION [MW]	27 126
Thermal power plants	18 898
Hydro power plants	141
Wind farms	782
Photovoltaics	7 305
TOTAL EXCHANGE BALANCE [MW]	1 817 EXPORT

DAY	19-02-2025 17:45
DEMAND [MW]	24 694
GENERATION [MW]	23 430
Thermal power plants	22 243
Hydro power plants	988
Wind farms	199
Photovoltaics	0
TOTAL EXCHANGE BALANCE [MW]	1 367 IMPORT


Fig. 2. Balancing the needs of the National Power System when generation from weather-dependent sources is significantly limited.

ing capabilities and competences of companies servicing power plants.

The operation of coal-fired units in an increasingly flexible mode of operation, necessary for the security of the energy system, is associated with a number of technical, economic and organizational risks.

Flexible operation of coal-fired power units increases the intensity of thermo-mechanical and physicochemical damage (all types of corrosion and erosion). The temporary safety criterion should be supplemented/replaced by a criterion that takes into account the history and operating conditions. Planning the scope of tests should take this into account. Failure analysis should take into account the impact of changed operating conditions and try to recommend solutions that counteract or limit future events of this type. In addition to high „classic" technical competences in the field of diagnostics, new ones should be acquired intensively and the exchange of knowledge and experience should be ensured.

The economic effects of flexible work put pressure on the need to optimize the expenditure on maintenance of technical condition. The knowledge and competence of the staff determine the possibility and effectiveness of such a procedure. The organization of maintenance appropriate to the new needs can significantly reduce the risks related to the new mode of operation of coal-fired power plants.

Maintenance skills – an important factor in energy security

The decommissioning of coal-fired units is accompanied by a gradual reduction in the activities of companies performing maintenance. A noticeable weakening of competences also in the field of diagnostics is observed. This is a predictable, natural process, the negative effects of which can be largely avoided. For almost twenty years, we have been creating diagnostics organized in a systemic manner, the basis of which was the registration of the history and condi-

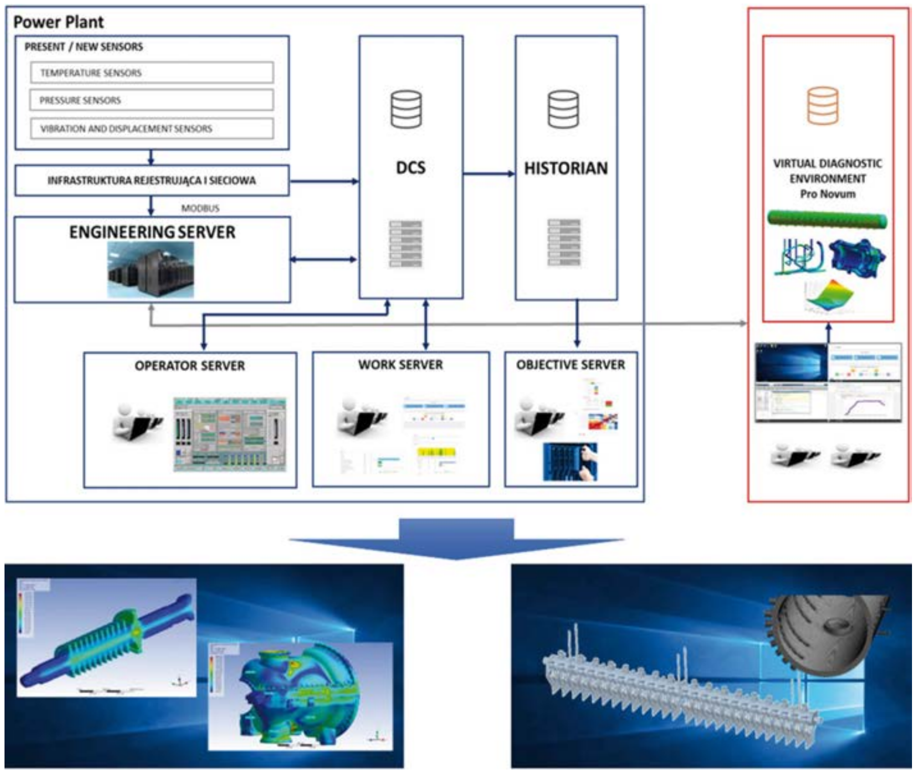

Fig. 3. Virtual Diagnostic Environment enabling joint work of specialists from the diagnostic company and maintenance of the power plant's production assets and their partners. The system also provides the possibility of supervision of the implementation of works by external institutions.

tions of operation and the analysis of failure rates [2, 3]. The LM System PRO+® diagnostic system [3] implemented criteria for assessing the technical condition and predicting durability according to available domestic and foreign standards (including vgbe) and based on our own knowledge and experience. The above-mentioned diagnostic system had many versions and is still evolving. For several years, it has been accompanied by a virtual diagnostic environment, which was, among others, successfully used to implement a method for improving the flexibility of 200 MW class units (Figure 3) [4]. All versions of the diagnostic system operate remotely and meet cybersecurity requirements.

The latest version of the above-described system is the Diagnostic System LE-FO® (Figure 4). It is designed for diagnostic supervision of power units operated in flexible mode. It uses digital twins of critical elements of the unit's thermo-mechanical devices and stress criteria to assess their technical condition, as well as fracture mechanics criteria to assess the safety of elements with detected cracks and with the possibility of their conditional operation.

LE-FE System PRO® integrated with the power unit is the most reliable source of knowledge and competence in the field of its technical maintenance, regardless of the further scenario of the last phase of its operation [1, 5-8]

LTSA supporting competences in the final phase of coal-fired units' operation

Providing the necessary competences of the personnel as well as the technical capabilities of the companies performing diagnostics and repairs can be achieved with the best effect by performing service in the LTSA mode at least in the period from the last major overhaul of the unit. Such service should cover not only the basic thermal and mechanical devices but also all those that significantly affect the availability of the unit.

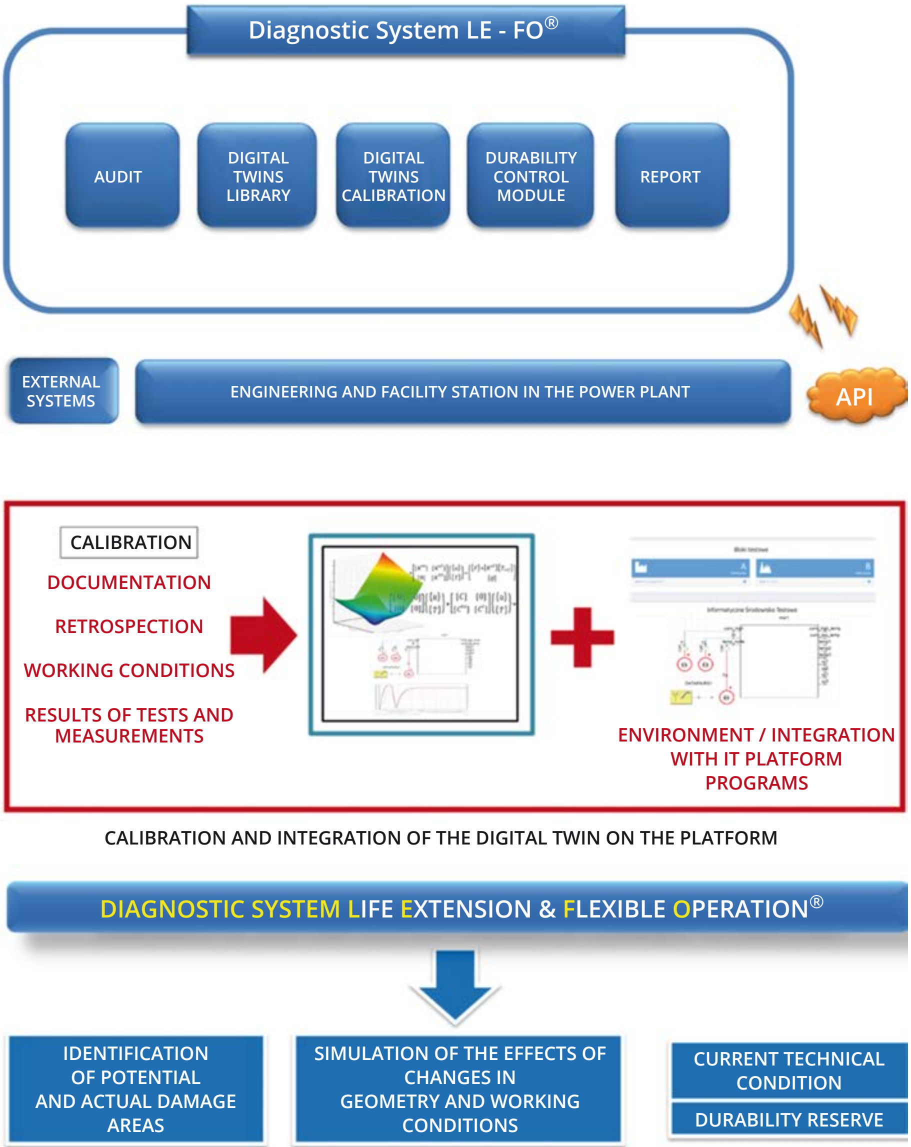

Fig. 4. Diagnostic system ensuring ongoing monitoring of the technical condition of coal-fired units operated in flexible mode also in the operational reserve mode. Critical elements and pipeline installations were implemented in the form of parametric digital twins.

LTSA/LTDSA service performed by repair and diagnostic companies seems to be the easiest way to avoid problems, the presence of which can already be noticed. For users of units that have been in operation for a long time, the LTDSA (Long Time Diagnostic Service Agreement) formula is particularly recommended, which provides diagnostics with an advantage and autonomy in relation to diagnostics performed for the needs of the repair company. This is important not only when performing post-failure expertise but can be a source of corporate knowledge, which may be important when making unusual decisions related to the end of operation and the further fate of the units. Diagnostics, when part of LTSA services, should have as much autonomy as possible, which ensures the objectivity of the assessment of the technical condition.

The most important benefits of LTSA/LTDSA services, from the point of view of the user of units in the final phase of exploitation, are as follows:

- Long-term nature: contracts are concluded for many years, which ensures cost stability and the availability of the repair and diagnostic company.
- Costs: a pre-determined price for a service or a payment model makes it easier to predict expenses, manage budgets and plan costs for maintaining the technical condition of devices.
- Flexible billing: contracts often include flexible terms, such as changes to test schedules depending on the actual technical condition of the equipment.
- Modernity: as part of the service services, suppliers provide remote diagnostic systems that inform the User about irregularities on an ongoing basis.
- Risk management: some of the risk can be transferred to the service provider, because they are responsible for ensuring the correct technical condition of the devices, which minimizes the risk of failures and unplanned downtime.

Summary

Coal-fired power plants, in the final phase of operation, have an important role to play, they should ensure the safe transformation of the power system with a growing share of generation from weather-dependent renewable energy sources. The lack of large-scale energy storage means that their operation is becoming increasingly regulated, which is why their operating costs are increasing, production assets are subject to faster degradation, while their most expected feature is high availability. This process makes the role of competences and technical capabilities of service companies ensuring the maintenance of the technical condition of critical infrastructure at an appropriately high level increasingly aware. This type of situation could be relatively easily predicted, hence the described approach to ensuring competences has a long, almost 20-year history. Based on knowledge from advanced diagnostics supplemented with the experience of foreign companies and institutions, it was implemented in diagnostic systems, giving diagnostics a systemic and remote character. The use of digital twins in an appropriate software environment allows the use of stress criteria, more accurate than temperature criteria, when assessing the current safety of critical elements of thermo-mechanical devices. This enables safe use of durability reserves, which is especially attractive for users of long-operated units, as it reduces the costs of adapting them to flexible operation. For the unfortunately decreasing group of specialists with the highest qualifications, a Virtual Diagnostic Environment has been created, connected via an engineering station with specialists in maintaining the assets in the power plant and the unit operator. The closure of the system, which should provide competences at a level ensuring the availability of units stabilising the power system, should be the maintenance of the technical condition of the units in the LTSA mode, preferably in its LTDSA version, because it provides knowledge about the current technical condition of the power unit not only to the company appointed to maintain the technical condition but also, at the same time, to its user.

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Kurzfassung

Sicherung der Kompetenzen und des Know-hows für den Betrieb von Kohlekraftwerken in Zeiten ihres Ersatzes durch erneuerbare Energiequellen

Für absehbare Zeite kann die Energieversorgungssicherheit in vielen europäischen Ländern ohne den weiteren Betrieb von Kohlekraftwerken nicht gewährleistet werden. Dies gilt auch für Polen, wo Braunkohle und Steinkohle etwa 60 % der Stromerzeugung sichern. Die letzte Phase des Betriebs von Kohlekraftwerken ist mit vielen Unbekannten verbunden. Während ihre Betriebsbedingungen zunehmend von denen abweichen werden, für die sie ausgelegt wurden, könnte es aufgrund der wirtschaftlichen Auswirkungen auf den Betrieb eine Herausforderung sein, ihren technischen Zustand entsprechen Standards aufrechtzuerhalten, die für ihre Verfügbarkeit als flexible und stabilisierende Energiequelle erforderlich sind. Kompetenzen und Know-how bei der Aufrechterhaltung des technischen Zustands werden entscheidend sein, um diese Erwartungen zu erfüllen.

Ein wichtiger Teil der Instandhaltung ist die Diagnose als Quelle für Erkenntnisse über den aktuellen technischen Zustand. Moderne analytische, digitale und IT-Technologien verbessern ihre Möglichkeiten erheblich. Geschickt eingesetzte Algorithmen können Fachkräfte ersetzen, deren Mangel immer deutlicher wird. Eine maßgeschneiderte Organisation der Instandhaltung, einschließlich Diagnosedienstleistungen, kann die Risiken, die mit dem längeren und flexibleren Betrieb von Kohlekraftwerken verbunden sind, erheblich reduzieren.

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