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Education indicators and decision analytics: A basis for using renewable energy sources and knowledge management

Jelena Malenovic-Nikolic[1,*], Bojana Zlatkovic[2] and Lidija Milosevic[3]

[1] Faculty of Occupational Safety, University of Niš, Niš, Serbia

* Correspondence: jelena.malenovic@znrfak.ni.ac.rs

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Abstract

Knowledge about decision analytics and knowledge management is essential when it comes to using renewable energy sources. Strategic energy management and education indicators play an important role in the application of modern technologies. Knowledge management can provide significant long-term energy benefits while requiring the same level of financial investment. The use of renewable energy sources necessitates a high level of knowledge management, particularly during the installation phase. Importing modern energy plants in the energy sector is possible, but it is not always the best solution. This paper discusses the importance of knowledge management and having educated personnel. Engineers need to know how to perform tasks related to the installation and maintenance of alternative energy plants. Education indicators are essential for avoiding problems and ensuring effective strategic management. Knowledge is a key resource that provides a competitive advantage in the European market. One of the most crucial requirements for achieving the energy policy goals is the Energy Sector Development Strategy of the Republic of Serbia up to 2025, with projections up to 2030. Effective education indicators and adequate decision-making in the field of applying renewable energy sources are also crucial for the maintenance of installed equipment. A lack of knowledge management during the implementation phase can lead to shorter exploitation periods and technical problems.

Keywords: education indicators, decision analytics, strategic energy management, energy sector.

1. Introduction

Strategic knowledge management, as an important factor in market survival, offers a number of benefits in terms of energy and technological development. The education of new employees is influenced by appealing educational programs and the already established cost of labour.

Long-term competitive advantage can be achieved by identifying market needs and investing in knowledge. It is becoming more and more important to take intellectual capital into account, Malenovic-Nikolić et al. (2024), not just economic resources. A high level of knowledge leads to financial gains, and ensures environmental protection and safe working conditions at the same time. Therefore, it is necessary to create and adopt a

knowledge management strategy at the national, regional, and local level. The process of knowledge management at the enterprise level indicates the fact that the employer is starting to recognize the value of key resources for business improvement. A basic case study that examines the operations of a wind park installation company can highlight the significance of this knowledge. In this case, importing obsolete equipment for wind energy applications has many shortcomings – it does not provide a 25-year use period, Malenovic-Nikolić et al. (2024), and it requires a huge space for storing propellers that have reached the end of their useful life. In this case, in a short period of time, the employer must plan the purchase of wind generator storage space, pay off the equipment, and invest significant funds in maintenance. Using knowledge to choose more modern and energy-efficient wind generators improves the financial benefit and reduces the payback period.

Innovations and finance**,** based on the application of circular economy principles (Agrawal et al., 2024), along with the use of business intelligence and innovation performance (Aljawarneh, 2024)**,** lead to knowledge management in modern organizations (Khmaaj et al., 2024)**.** Artificial intelligence as a driver of future development (Guerreiro et al., 2024; Yadav et al., 2024), is playing an increasingly important role in human resource management and innovation (Cleland Silva and Hämäläinen, 2024)**.** European Union legislation in the field of energy as well as in renewable energy sources**,** represents a key factor of development (Daoudi, 2024) and of strengthening the financial sector (Đurić et al., 2024). Strengthening the educational structure (Ilic et al. (2024a)**,** as well as considering **s**ustainable development (Ilic et al., 2024b), represents a significant challenge for banking transactions (Martin, 2024), but also for risk and knowledge management (Sukharev, 2024)**.** The impact of renewable energy sources on the environment can also be based on an analysis of education in the process of reducing fire risk (Hamed and Alshare, 2022; Vaverková et al., 2022).

The paper presents the importance of intellectual capital for application in the field of modern renewable energy sources**.** Adherence to legal regulations and principles of sustainable development contributes to the development of the energy sector. One of the key requirements for sustainable energy development is the education of workers in maintaining modern energy plants**.** The paper is based on an analysis of workforce estimates needed for the implementation of solar power plants**,** wind generators**,** and biomass processing plants**.** The planned production capacities within the Energy Development Strategy of Serbia are also analyzed. The knowledge management model presented in the paper implies cooperation between educational institutions and representatives of modern energy plants**.**

2. Education indicators guidelines of sustainable energy sector

The development of a sustainable energy sector should be based on the use of renewable energy sources, as well as the possibility of saving fossil fuel reserves. Improving the technology for converting raw materials into electricity in its final form also implies opening new vacancies. It is unrealistic to expect that new technologies will be implemented through retraining processes. In specific cases, miners should be given the option to continue with their regular jobs, but not to be authorised to install and maintain solar power plants or wind generators.

Opening job vacancies for performing installation of modern energy plants requires the education and training of workers for suitable positions. Educating workers is a requirement by which all operations must be carried out with the proper application of safety measures and workplace health and safety legal requirements.

The Energy Development Strategy of the Republic of Serbia, until 2025 with projections until 2030 (2015) looks to replace the use of coal with renewable energy sources while considering the possibility of ceasing operations for coal-fired thermal power plants. The goal of new strategic solutions must be based entirely on education indicators. Otherwise, Serbia expects to import not only modern energy technologies but also investments in foreign intellectual capital.

Figure 1 depicts the planned share of renewable energy sources in Serbian electricity production until 2050 (Integrated national energy and climate plan of the Republic of Serbia for the period up to 2030 with projections up to 2050, 2023).

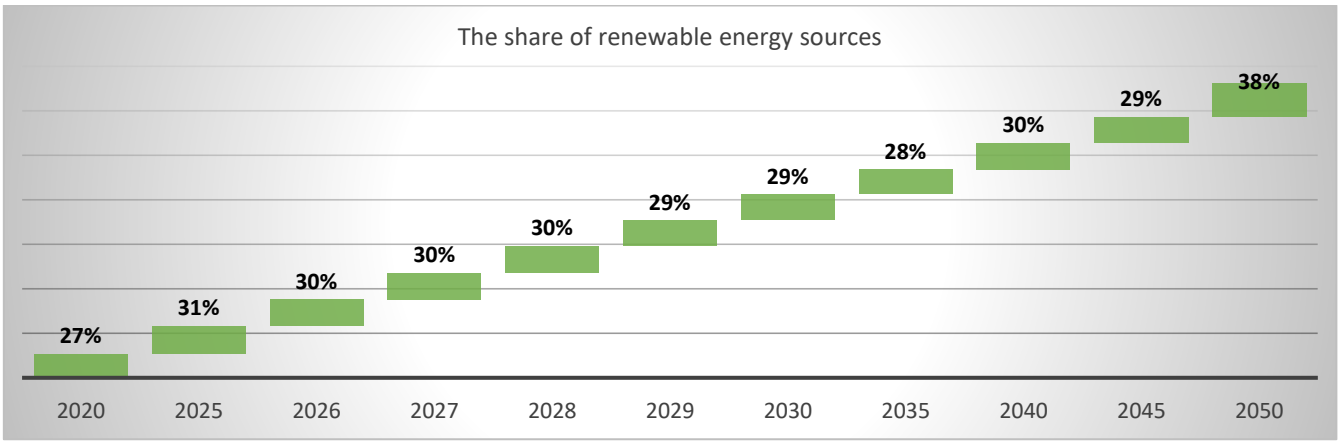

Figure 1. The share of renewable energy sources in the production of electricity in the 2020-2050 period

Be Based on Figure 1, which depicts the projected development of the renewable energy sector, it is concluded that the period after 2040, when a significant need for professional staff is anticipated, should be prepared. Although the picture shows a consistent trend in the share of clean technologies, it should be noted that a reduction in the use of fossil fuels is expected even sooner due to obligations to the European Union.

Figures 2 and 3 show the base index and the chain index of energy sector development. The base year is 2025.

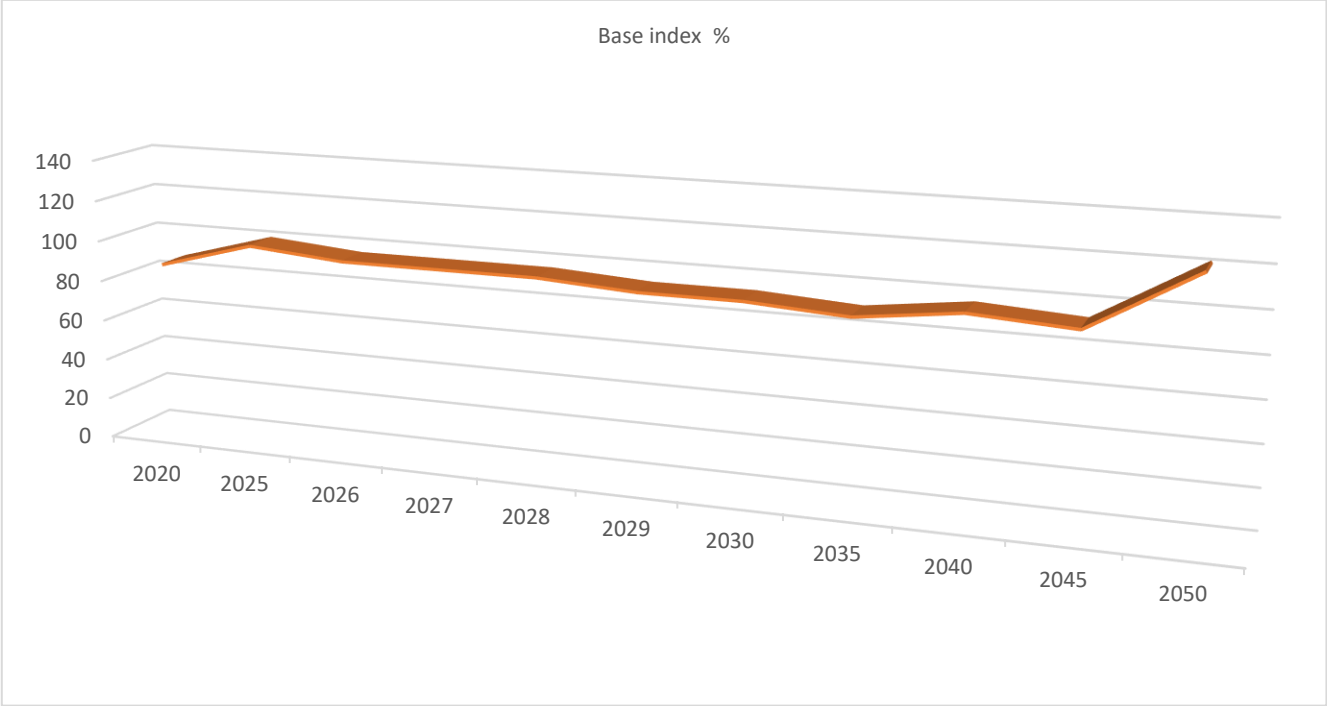

Figure 2. Base index as an indicator of energy development

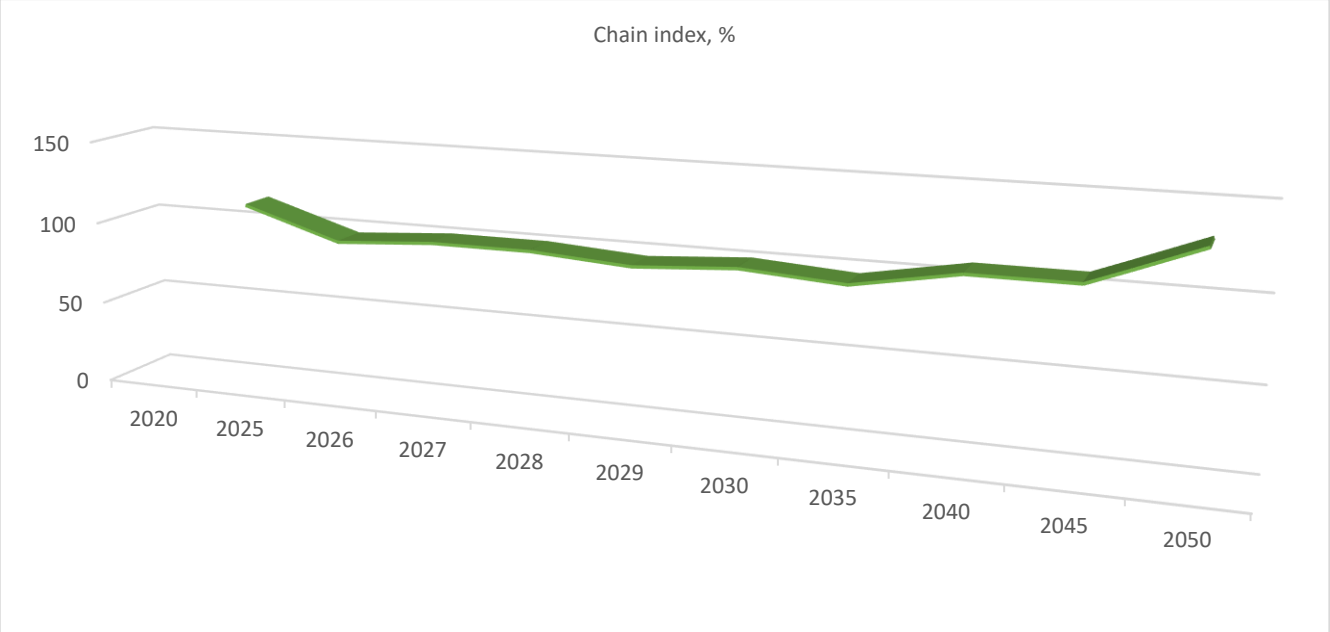

Figure 3. Chain index as an indicator of energy development

Figures 2 and 3 show that no significant development of the energy sector is expected.

The process of redirecting intellectual capital to renewable energy sources should begin as soon as possible, as there are real needs even earlier. Figure 4 shows the intensity of CO2 reduction per gross domestic product (GDP), (Integrated national energy and climate plan of the Republic of Serbia for the period up to 2030 with projections up to 2050, 2023).

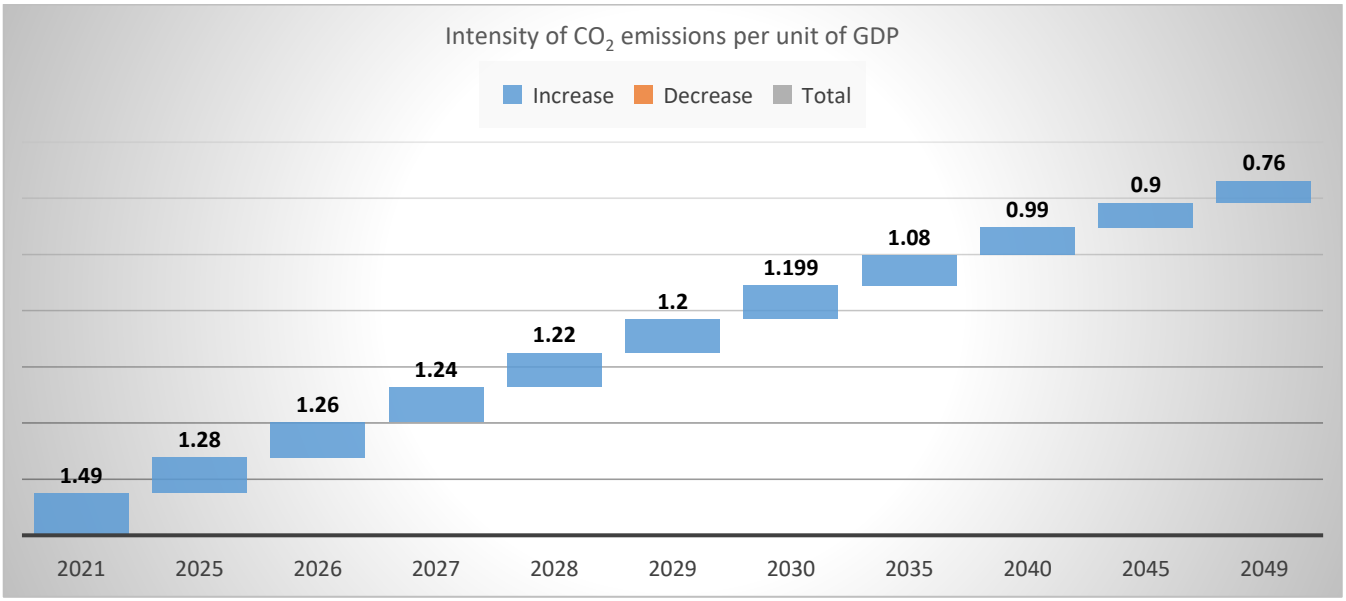

Figure 4. Intensity of CO_2 emissions per unit of GDP (kg CO_2 from energy sources/ € GDP), in the 2020-2050 period

Figure 4 clearly shows that CO_2 emissions per unit of gross social product are expected to decrease beginning in 2030. Based on this, it is concluded that, in addition to training personnel for the use of renewable energy sources, it is necessary to invest in the retraining of workers who will be responsible for the maintenance of the air purification system.

Table 1 shows the estimated number of workers needed for the installation, operation, and maintenance of solar power plants, wind farms, and biomass processing plants (Integrated national energy and climate plan of the Republic of Serbia for the period up to 2030 with projections up to 2050, 2023).

Table 1. Employment indicators depending on of power plant

Work activities	Power plant		
	Solar power plants	Wind turbines on land	Plants for biomass
Installation (Person-year/MW)	10-15	10-15	15-20
Work and maintenance (Jobs/MW)	0.2-0.4	0.2-0.4	0.2-0.4

The data from Table 1 show that the number of qualified workers depends on the installed capacities.

Planning should be completed during the first knowledge management phase, taking into account the projected modern installed capacities. The phase of organizing educational activities in the energy sector should not be delayed, as training personnel for the tasks of installing and maintaining power plants is a complex process. Relying on international staff has a significant impact on the decision-making process in the implementation and control phases, but also on the use of electricity.

3. Decision Analytics in the field of renewable energy sources and Education Indicators

Knowledge management planning in the field of renewable energy sources requires the implementation of development plans for wind, solar, and biomass energy. Assessments are primarily based on studies about existing experiences. Many studies have been conducted to assess the number of new jobs in EU countries. Appropriate data should be obtained from countries with similar characteristics to the Serbian energy sector and available energy resources.

Based on experience in EU countries, the construction time for energy plants is estimated to be one year for solar power plants and two years for wind and biomass power plants, (Integrated national energy and climate plan of the Republic of Serbia for the period up to 2030 with projections up to 2050, 2023).

Figures 5, 6, and 7 show job estimates resulting from the introduction of new energy capacities based on renewable energy sources such as wind, solar, and biomass, (Integrated national energy and climate plan of the Republic of Serbia for the period up to 2030 with projections up to 2050, 2023).

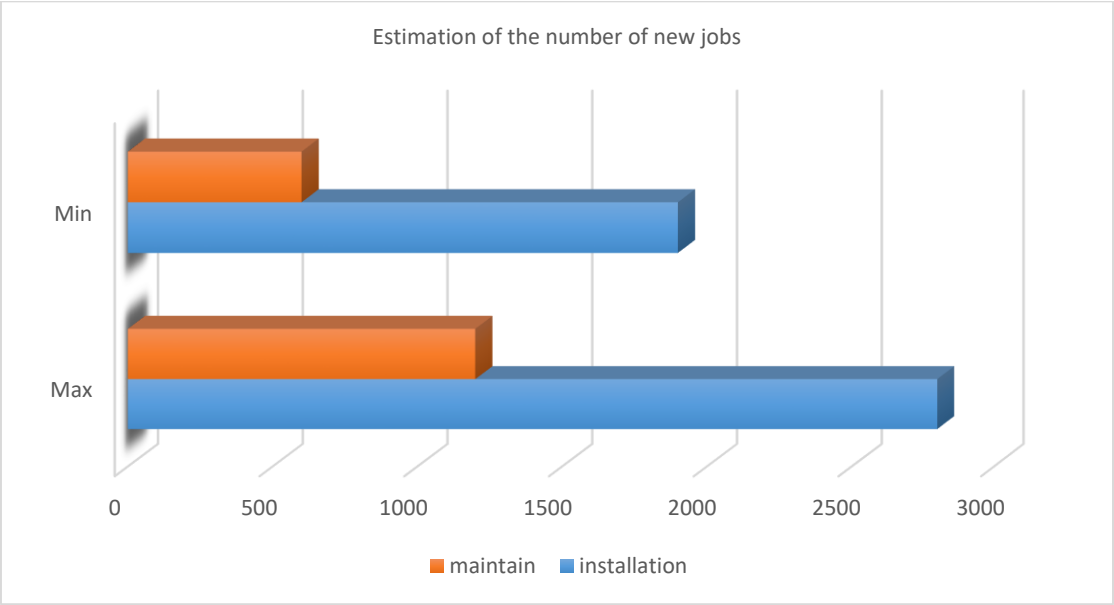

Figure 5. Estimation of the number of new jobs resulting from the introduction of new wind energy capacities

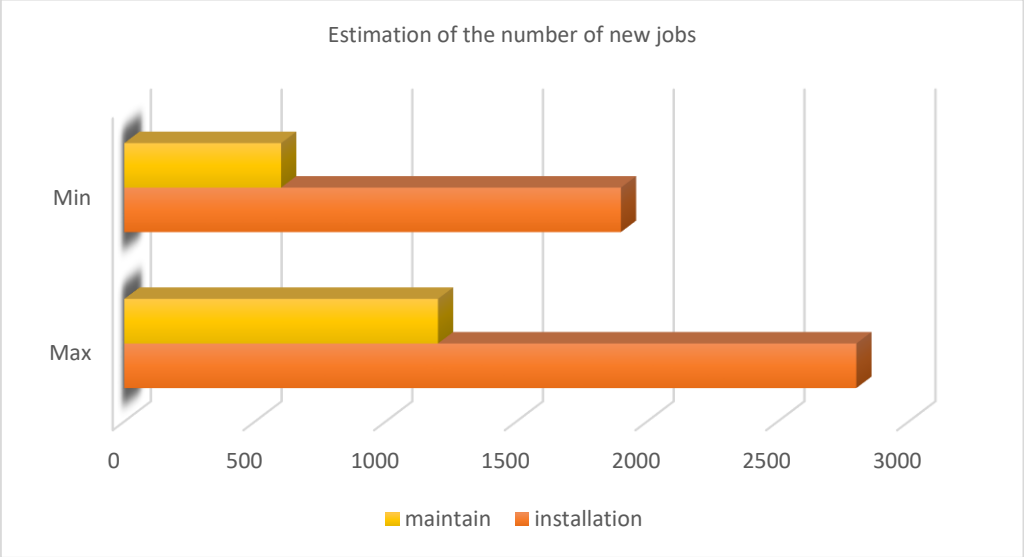

Figure 6. Estimation of the number of new jobs resulting from the introduction of new solar energy capacities

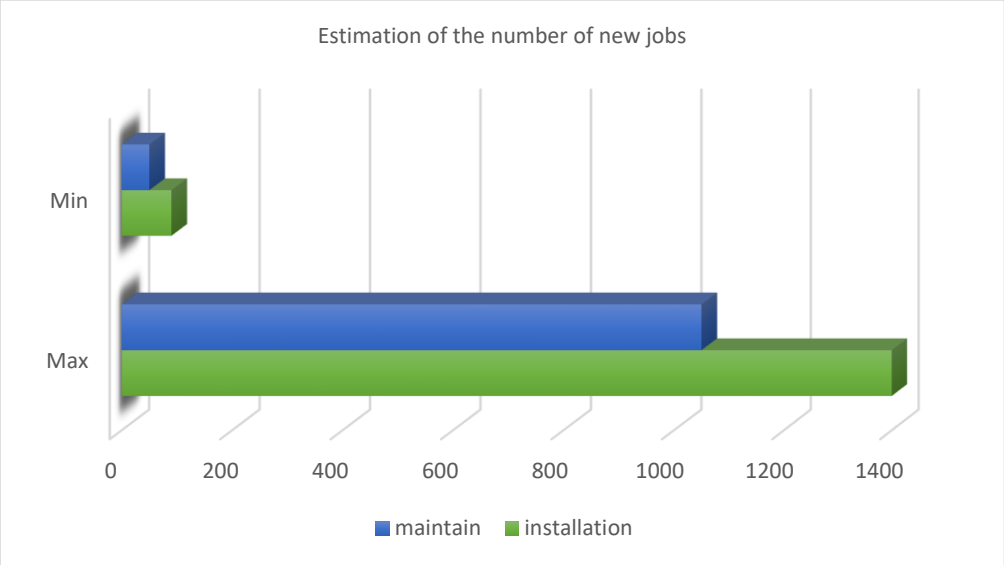

Figure 7. Estimation of the number of new jobs resulting from the introduction of new biomass energy capacities

Figures 5, 6, and 7 (Integrated national energy and climate plan of the Republic of Serbia for the period up to 2030 with projections up to 2050, 2023), show that the required number of workers was assessed for the period up to 2030 and that it encompasses the maintenance and installation of additional capacity.

Figure 5 shows that 1,900 to 2,800 new workers will be hired to complete the wind power plant installation, as well as 600 to 1,200 workers to maintain the wind energy transformation system.

Figure 6 shows that a similar number of workers should be provided for solar power plant installation, but fewer workers are required for maintenance (from 300 to 600).

The installation of a power plant for biomass processing is expected to secure employment for 1,050–1,400 additional workers, as seen in Figure 7. In this case, approximately 100 workers will be assigned to the maintenance of the biomass processing plant, which is the smallest number of workers among the analysed power plants.

Assessments show that there is an urgent need for highly qualified employees, so it is critical to begin the process of knowledge management in the field of renewable energy sources immediately. The required number of workers for the expansion of the electricity distribution network should be considered in addition to the estimated number of workers; however, Serbia is thought to have the necessary personnel.

4. Knowledge management model in the field of sustainable energy resources

Knowledge management in the field of renewable energy sources largely depends on national energy policies, the adopted energy development strategy, assumed international obligations (Daković, 2022), and financial resources. Apart from the aforementioned variables, the execution of energy-related plans also depends on the preparedness of potential students to acquire knowledge and recognize the perspective of the developments in the energy sector. It is necessary to inform the public about national plans so that potential candidates can adopt modern knowledge. Implementing study programs related to the use of renewable energy sources is also a significant challenge, especially in conditions where faculties, despite students' lack of interest, continue to implement programs that do not provide a competitive advantage in the labour market. In Figure 8 the model of decision analytics and education indicators in the field of renewable energy sources is presented.

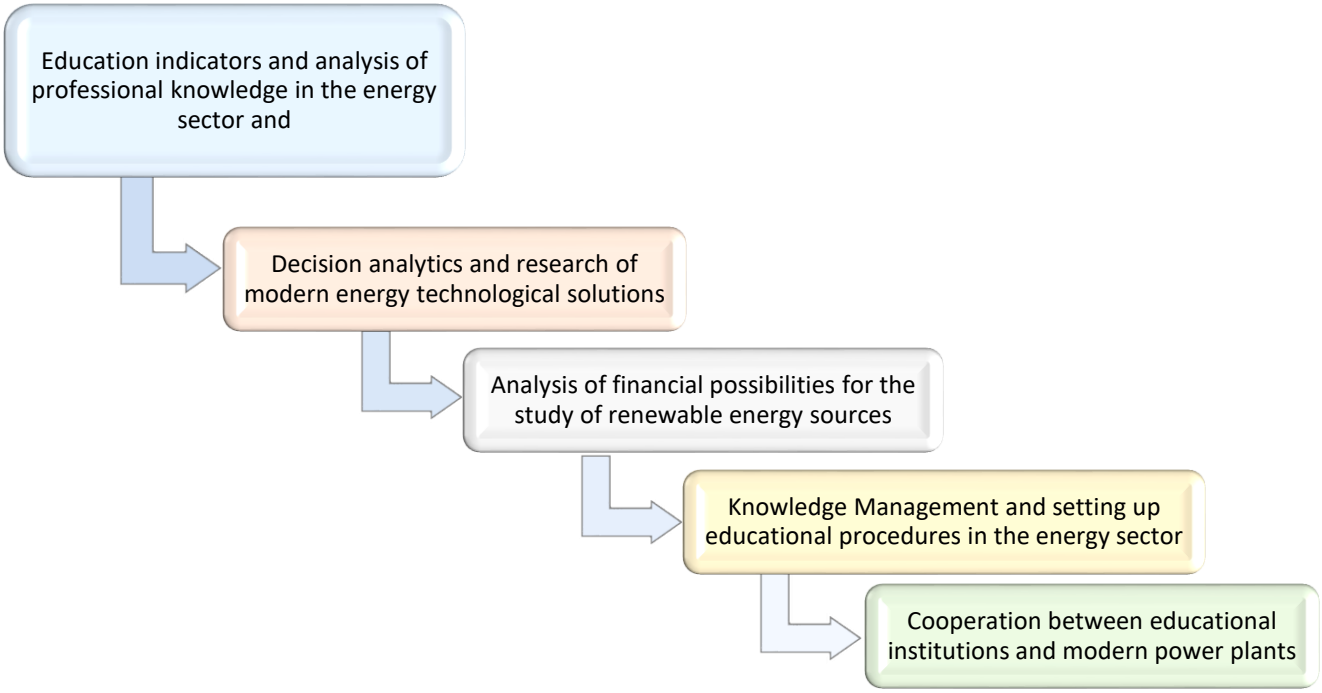

Figure 8. Model of decision analytics and education indicators in the field of renewable energy sources

Teaching programs that have no real application and are not innovated in accordance with the development of new technologies pose a unique challenge in the knowledge management process.

Information that is currently available remains an unused strategic resource unless people apply specific skills and knowledge in the fields of innovation, design, installation of new technologies, and maintenance of modern energy systems. The interval between the introduction of contemporary technology and the time it takes to carry out plans and make decisions presents a unique challenge, because the lack of readiness slows down technological development.

The use of advanced technologies, grounded in professional expertise, necessitates continuous learning and the timely application of acquired skills. Energy managers have a significant responsibility to support the

development of energy because, since in the process of obtaining the necessary licenses, they learn about legal norms, energy transformations, and management.

Data from show that the number of qualified workers depends on educational plans. Participation in decision-making should require the application of useful knowledge.

5. Knowledge management and renewable energy sources

Specific technological achievements, in the field of renewable sources, affect sustainable energy development. A wind system with a 20-year life expectancy results in an average of 40.7 g CO2/kWh, and 30-years reduces it to 25.3 g CO2/kWh (Hamed and Alshare, 2022).

The life expectancy of solar and wind energy systems has a significant impact on greenhouse gas emissions. The majority of greenhouse gasses for PV and wind are generated during the extraction and manufacturing and installation process. Thus the longer life expectancy the lower greenhouse gas emissions through the whole life of the system (Daoudi, 2024). Effective knowledge and strategic management are key to realizing the needs of stakeholders, over a longer period of time. Community engagement and awareness are emphasized as crucial factors in renewable energy education (Intelligent energy-Europe Programme, 2010).

The energy sector in Serbia, based on renewable energy sources, is developing. Strategic knowledge management includes the accreditation of new educational programs in the field of energy. In Serbia, engineers of renewable energy sources are educated in Beograd, Novi Sad, Niš and Kragujevac. Schools in Nis, Pirot, Kula and Sombor educate technicians of renewable energy sources.

Table 2 shows the educational process activities related to power plants, which are carried out in Serbia within the course Renewable Energy Sources at faculties of mechanical engineering.

Table 2. Education and renewable energy sources

Faculty - basic academic studies	Elective course at the faculty	Application of renewable energy sources	practical application
Faculty of Mechanical Engineering, Beograd	Basics of solar systems	/	/
	Renewable energy sources	/	/
Faculty of Mechanical Engineering, Niš	Renewable energy sources	supervision during construction, exploitation, maintenance	calculation exercises
Faculty of Engineering Sciences, Kragujevac	Renewable energy sources	construction, use, maintenance	study research work

The number of pupils and students is small compared to the plans foreseen in the Energy Sector Development Strategy. Advanced countries invest more in training workers to solve specific problems, in the area of safety, risk, energy efficiency and the environment.

Concrete examples of the application of knowledge management strategies in the field of energy still represent a corporate advantage. Fossil fuel reserves are low, and renewable resource technology is improving. Competitive

advantage is achieved by applying more energy efficient systems. Knowledge sharing is not at a high level in the energy industry.

The problem can be solved by creating knowledge management tools. It is necessary to integrate knowledge management software into existing management systems. In this way, the objectives of the application of renewable energy sources can be harmonized with the development of technology. Using feedback and a systemic approach to problem solving contributes to sustainable energy development.

Table 3 shows the activities of the education process related to wind energy, solar energy and biomass energy.

Table 3. Education - application of renewable energy sources

Faculty of Mechanical Engineering, Niš	Power plant	Application of renewable energy sources
Basic academic studies	Wind energy	construction of renewable energy sources
		application of renewable energy sources
	Solar energy	application of renewable energy sources
	Biomass energy	application of renewable energy sources

Organizations in the energy sector can implement and improve practical knowledge management systems. The advantage of applying intellectual capital is the use of the latest technologies.

The Build Up initiative was launched at the European level, which includes 30 projects in 30 European countries financed within the CIP Intelligent Energy Europe program (Intelligent energy-Europe Programme, 2010). The goal of the initiative is to bring together relevant people to work on achieving the necessary skills of workers.

Comparative analysis can contribute to the comparison of the results of the work of different energy sectors. It is necessary to create a set of clear, relevant and measurable indicators. Before that, the area of application and the type of renewable source should be defined. Key indicators in the field of wind and solar energy use should be based on fire indicators and knowledge management indicators.

The comparative analysis provides the necessary data for the development of the energy sector. The causes of fires at photovoltaic power plant (PVPP) sites vary and the most common causes include the faulty installation of quick couplers or the selection of incorrect quick couplers, inadequate cable routing, failure to use shields on them, or the use of inadequate adapters, which can lead to electric arc formation that directly causes fires. Sometimes, there are design errors, including too many parallel connections, that have affected several installations. Occasionally, fires are caused by animals that damage the installations. This means that fires are started by the panels and then proceed to the soil surface and vice versa Vaverková (Vaverková et al., 2022).

The analysis further explores pedagogical approaches, learning tools and the training required for educators and trainers in the field of renewable energy (Intelligent energy-Europe Programme, 2010). Organizations can conduct joint research and solve problems together. Development of a strategic plan includes: development of a training program, selection of quality lecturers, creation of knowledge management indicators and consideration of specific problems.

6. Conclusion

Knowledge management, whether in the energy sector or elsewhere, is essential for improving technological processes, preserving environmental quality, and increasing worker safety. If the knowledge management process yields positive results, the acquired intellectual capital should be considered a national asset that should be retained in the country rather than transferred to other countries that understand how to value it.

The education of experts, for which there is a real need during the implementation of installation and maintenance tasks for modern power plants, is a prerequisite for the development of the entire economy. Modern knowledge and a practical problem-solving approach form the foundation for enhancing the country's intellectual capital**.**

Educational processes must align with the needs of energy capacity development and should not be viewed as unjustified expenses. Organizing educational processes at the national level requires a comprehensive analysis of acquired knowledge, along with the ability to develop curricula and programs to overcome identified issues.

Education also requires financial support for the study of modern energy technologies, combined with strong access to practical knowledge.

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References

Agrawal, R., Agrawal, S., Samadhiya, A., Kumar, A., Luthra, S., & Jain, V. (2024). Adoption of green finance and green innovation for achieving circularity: An exploratory review and future directions. Geoscience Frontiers, 15(4), 101669.

Aljawarneh, N. M. (2024). The Mediating Role of Organization Agility between Business Intelligence & Innovative Performance. Journal of Statistics Applications & Probability, (13)3, 929-938.

Cleland Silva, T. C., & Hämäläinen, M. (2024). Innovating for the Future: AI and HRM Capabilities for Sustainability in Higher Education. Academy of Management Proceedings, 2024(1). https://doi.org/10.5465/AMPROC.2024.19249abstract, Accessed 13 July 2024.

Daković, D. (2022). Energy legislation of the European Union. Bilten - European energy regulatory policy, Analyzes, news, views, no. 555. https://aers.rs/media/g/vesti/file/Bilten/2021/21-12-28%20BILTEN%20VESTI.pdf, Accessed 13 July 2024.

Daoudi, M., (2024). Education in renewable energies: A key factor of Morocco's 2030 energy transition project. Exploring the impact on SDGs and future perspectives. Social Sciences & Humanities Open, 9, 100833.

Đurić, Z., Ilić, B., & Khmaaj, A. A. M. (2024). Managing Changes and Innovations in Companies - Aspects of Green Finance. Proceedings of the 6th Virtual International Conference Path to a Knowledge Society-Managing Risks and Innovation (PaKSoM) (pp. 295-302). Belgrade: Mathematical Institute SANU.

Energy Development Strategy of the Republic of Serbia until 2025 with projections until 2030. (2015). Official Gazette of the Republic of Serbia, no. 101.

Guerreiro, J., Rebelo, S., & Teles, P. (2024). Regulating Artificial Intelligence. National Bureau of Economic Research, Working Paper No. 31921. https://www.nber.org/papers/w31921, Accessed 13 July 2024.

Hamed, T. A., & Alshare, A. (2022). Environmental Impact of Solar and Wind energy- A Review. Journal of Sustainable Development of Energy, Water and Environment Systems, 10 (2), 1-23.

Ilic, B. S., Djukic, G. P., & Ostojic, B. S. (2024a). Inclusive Education Project Methods to Strengthen Educational Infrastructure. In N. Baporikar (Ed.), Infrastructure Development Strategies for Empowerment and Inclusion (pp. 234-257). Hershey, New York, London, Beijing: IGI Global.

Ilic, B., Ostojic, B., Stojanovic, D., & Djukic, G. P. (2024b). Consideration of the Path of Sustainable Development and Green Activities. In A. Taghipour (Ed.) Applications of New Technology in Operations and Supply Chain Management (pp. 58-84). Hershey, New York, London, Beijing: IGI Global.

Integrated national energy and climate plan of the Republic of Serbia for the period up to 2030 with projections up to 2050. (2023). Official Gazette of the Republic of Serbia, no. 46.

Intelligent energy - Europe Programme. (2010). Implementation report. https://ec.europa.eu/cip/files/docs/final_iee_implementation_report_2010_en.pdf, Accessed 13 July 2024.

Khmaaj, A. A. M., Ilić, B., & Čabarkapa, O. (2024). Green Financing and Knowledge Management in Modern Organizations. Proceedings of the 6h Virtual International Conference Path to a Knowledge Society-Managing Risks and Innovation (PaKSoM) (pp. 279-286). Belgrade: Mathematical Institute SANU.

Malenović-Nikolić., J., Lukić, M., & Ranđelović., A. (2024). Knowledge Management: A Basis for using Renewable Energy Sources. Proceedings of the 6h Virtual International Conference Path to a Knowledge Society-Managing Risks and Innovation (PaKSoM) (pp. 19-24). Belgrade: Mathematical Institute SANU.

Martin, V. (2024). Integrating artificial intelligence into central banking: opportunities, challenges, and implications. Journal of Process Management and New Technologies, 12(1-2), 49-60.

Sukharev, O. (2024). “Distributed” Management of the “Knowledge Economy”: “Income – Risk”. Proceedings of the 6h Virtual International Conference Path to a Knowledge Society-Managing Risks and Innovation (PaKSoM) (pp. 201-208). Belgrade: Mathematical Institute SANU.

Vaverková, M. D., Winkler, J., Uldrijan, D., Ogrodnik, P., Vespalcová, T., Aleksiejuk-Gawron, J., Adamcová, D., & Koda, E. (2022). Fire hazard associated with different types of photovoltaic power plants: Effect of vegetation management. Renewable and Sustainable Energy, 162, 112491.

Yadav, N., Sharma, L., & Dhake, U. (2024). Artificial Intelligence: The Future. International. Journal of Scientific Research in Engineering and Management, 8(1), 1-6.