MetaTech Exchange

BRIDGING INDUSTRY 4.0 IN WESTERN BALKANS

METAL INDUSTRY IN MONTENEGRO

CURRENT STATUS AND RECOMMENDATIONS FOR IMPROVEMENT

Co-funded by the European Union

1. Introduction and context of METATECH 4.0 project 2
2. Brief overview of the metal sector in Montenegro 2
3. Key actors and geographical distribution of the sector 5
4. Current labor market needs and competences 7
5. APPROACHES TO DIGITALIZATION AND INDUSTRY 4.0 9
6. OPPORTUNITIES FOR INNOVATION AND PARTNERSHIPS 11
7. RECOMMENDATIONS FOR FURTHER STEPS 12
8. CONCLUSION 13

1. Introduction and context of METATECH 4.0 project

Montenegrin Employers Federation (MEF) is a partner organization in Erasmus+ project MetaTech Exchange: Bridging Industry 4.0 in the Western Balkans (METATECH4.0). The project is designed in accordance with EU strategies for digitalization and innovation and addresses key challenges in metal industry and vocational education sector in the Western Balkans.

In the modern environment of rapid technological changes, digitalization and introduction of principles of Industry 4.0 impose the need for the transformation of traditional industrial sectors. The METATECH4.0 project was launched with the aim of identifying challenges and potentials in the metal sector of the Western Balkan countries, with a focus on empowering small and medium-sized enterprises (SMEs), improving workforce skills and strengthening regional cooperation through digital and technological integration.

Montenegro, although small in terms of market size, has certain industrial capacities in the field of metal processing that represent ~~a~~ potential for modernization and digital transformation. This analysis aims to present the current status of the sector, identify key challenges and propose recommendations for improvement within the objectives of the METATECH4.0 project.

2. Brief overview of the metal sector in Montenegro

The metal sector in Montenegro includes companies engaged in metal processing, production of metal structures, machine components, tools, as well as various metal products for industrial and construction use. These companies, although numerous, most often operate within micro, small and medium-sized companies, which represent the backbone of the economy in the sector.

Historically, metal industry was a pillar of the industrial development of Montenegro, especially in the period of socialist Yugoslavia. Podgorica Aluminum Plant (KAP) and Željezara in Nikšić were strategic industrial complexes that employed thousands of workers and had a high export value. According to the analysis contained in the monograph "Macroeconomic Development Model of Montenegro" (Fabris, 2021), [1] accelerated industrialization in the post-war period, supported by state investments, enabled significant industrial growth. However, the later transition, market liberalization and the lack of

[1] N. Fabris

systemic reindustrialization measures has contributed to deindustrialization and the shutdown of a large number of capacities.

Today, the metal sector is dominated by smaller production facilities, often based on family businesses and local supply chains. A significant part of the production is aimed at export, with the EU markets occupying a special place. Despite this, the sector faces serious challenges:

– Lack of qualified workforce, especially in areas such as welding, CNC processing and industrial automation;
– Technological obsolescence of equipment, which limits the possibility of introducing modern quality standards and increasing productivity;
– Weak integration of digital tools and solutions, including automation, digital manufacturing and production cycle management;
– Insufficient investment in research and development, both at the company level and through institutional support for innovation.

Despite these challenges, the sector has many potentials. The geostrategic position of Montenegro - including the proximity of the ports of Bar and Kotor, and access to free economic zones - represents a logistical advantage for export-oriented companies. In addition, the presence of educational institutions (e.g. technical faculties and vocational schools) in urban centers such as Podgorica, Nikšić and Bijelo Polje enables the creation of a personnel base to support reindustrialization.

However, additional concern among employers dealing with the metal industry was caused by the recent decision of the Competitiveness Council, which excluded production companies from sector C, including metal processing activities, from the competitiveness support program for the first time. This decision exclusively favors the food industry, which neglects the strategic importance of the metal sector for digital transformation and technological progress, which are the priorities of the METATECH4.0 project.

Businessmen also point to the previous year when, in addition to the available funds in the amount of 2.5 million euros, the competition was set up in such a way that it favored mainly large companies, while micro and small businesses were left without significant support. For the year 2025, the budget for the entire C sector is 1.3 million less, which represents a serious barrier to the realization of the idea of improving this sector.

In light of current challenges, the question arises regarding Montenegrin institutional readiness to follow the European trends, where the digitalization of industry and the circular

economy stand out as key areas of support. The opposite approach, which favors short-term interests, threatens the long-term sustainability and competitiveness of the national economy. Additionally, geopolitical instabilities and uncertainties in global supply chains require a proactive approach to reindustrialization and diversification of the economy, in which the metal sector must play a central role.

The economy of Montenegro particularly points to the need for a strategic shift towards digitalization**,** innovation and sustainable industrial policy, which fits perfectly with the goals of the METATECH4.0 project. Through adequate policies and coordination of key actors - state, education and economy - the metal sector can become the bearer of smart and inclusive industrial development in Montenegro.

3. Key actors and geographical distribution of the sector

Based on the available list of members operating within the metalworking sector, more than 30 active companies located throughout Montenegro - in Tivat, Nikšić, Podgorica, Pljevlja, Bijelo Polje and other municipalities - have been identified. These are mainly small and medium-sized enterprises (SMEs) that deal with the production of metal structures, tools and machines, components for industry, precision metal processing, shipbuilding and maintenance, as well as the use of CNC technologies.

The highest concentration of metal companies was recorded in the central and northern part of Montenegro, where the cities of Nikšić, Podgorica and Bijelo Polje stand out. Nikšić, as a former industrial center, still has a leading role thanks to the existing infrastructure, the presence of technical schools and the existence of companies that maintain the tradition of metalworking production.

What unites most companies in the sector is their small size, often family-business character and strong reliance on practical experience. Although many companies show interest in business improvement, most of them have limited internal capacities for introducing advanced technologies and digitizing processes. The lack of specialized technical staff, as well as limited access to funds for innovation, further slow down the modernization of the sector.

Despite this, the industry shows significant potential for growth – particularly in segments such as automotive component manufacturing, smart metalworking, energy-efficient construction and renewable energy equipment. Global trends indicate a growing demand for flexible, sustainable and digitally integrated production processes, which can open the door for domestic companies to strategic partnerships and access to wider markets. Connection of the metal sector with other branches - such as energy, construction, transport and innovative technologies - makes it one of the keys to overall industrial growth. According to analyzes published on relevant investment portals, metal processing in Montenegro has the potential to become a pillar of economic stability and growth, especially through the promotion of domestic production, the development of export capacities and the creation of quality jobs. Despite these advantages, systemic support and strategic direction for the development of the sector are still lacking. Most companies emphasize the need for better organized programs of professional education and training, in order to replace the chronic lack of qualified labor. At the same time, there is a visible regional imbalance - while in some areas there is a surplus of working-age population with basic technical knowledge, the absence of coordinated measures for retraining and lifelong learning leads to insufficient utilization of existing potential - while in some cities there is a surplus of working-age

population with basic technical knowledge, the lack of systematic programs of retraining and lifelong learning prevents better utilization of the existing potential.

4. Current labor market needs and competences

Considering the technological changes and requirements of modern production, the labor market in the metal sector of Montenegro is faced with a pronounced lack of professional staff with specific technical and digital competencies. The most popular profiles include:

- welders and operators of CNC machines;
- technicians for industrial automation;
- mechatronics;
- mechanical engineers with knowledge in the field of 3D modeling and CAD/CAM technologies.

Research by the Employment Agency of Montenegro (2024) confirms that occupations in field of mechanical and electrical engineering are among the most deficient at the national level. A particular deficiency was noted for:

- mechanical engineers;
- operators of CNC machines;
- welders;
- metal lathes;
- electrical technicians;
- automation technicians.

This shortage of occupations is characterized by a disproportion between the number of advertised positions and the number of available qualified candidates in the records of the Employment Agency. In many cases, employers were forced to replace the required workforce by hiring foreign workers. This trend is particularly present in the northern and central municipalities, where the links between educational institutions and the economy are poorly developed, and the system of retraining and lifelong learning is not functional enough.

In EAM analysis, it is additionally pointed out that, although secondary education dominates qualification structure of the supply, the employment is significantly lower than the demand - which points to a mismatch of knowledge and skills with the requirements of employers. A high rate of "undefined demand" is also noticeable, where employers advertise needs without a specific occupational specification, which further complicates strategic planning and interventions within the education system.

In addition to technical competences, the need for "soft skills" - such as the ability to work in a team, adaptability, problem solving and digital literacy - is becoming more and more pronounced, especially in the context of the introduction of the principles of Industry 4.0 and the increasing automation of production processes.

The system of secondary vocational education in Montenegro was modernized in previous years through the introduction of modular programs and competency-oriented curricula. However, there is still significant room for improvement, especially when it comes to better connections between schools and employers, more flexible adaptation of the curriculum to market needs and the spread of dual education models - which are still a rarity in many regions.

In the field of adult education, short specialized programs (micro-qualifications) are gaining more and more importance, which will enable quick and targeted acquisition of knowledge and skills. Such programs will be imposed as a key tool for retraining, reducing unemployment and strengthening the flexibility of the workforce. However, their effective implementation requires additional investments in infrastructure, teaching resources, as well as the construction of a flexible adult education system as well as a system for monitoring the quality and results of these trainings.

A more comprehensive approach to the development of human capital must also include better planning of enrollment quotas in accordance with data from the labor market, strategic investments in teaching staff and the establishment of regional centers for professional training that will serve as a link between education and the real economy.

5. APPROACHES TO DIGITALIZATION AND INDUSTRY 4.0

Digital transformation of the metal sector in Montenegro is in the initial stage of development and is characterized by a low rate of adoption of advanced technologies in most small and medium-sized enterprises (SMEs). Although there are several positive examples of companies that have started with the implementation of smart technologies, the sector still functions without systemic institutional support, a concrete industry digitalization strategy or a coordinated Industry 4.0 development plan at the national level.

Most SMEs use basic digital tools, such as design, administration and accounting software. However, the application of more advanced solutions - such as the Internet of Things (IoT), artificial intelligence (AI), automated production systems, digital simulations and digital factories - is still limited to a very small number of companies that mostly have international partners or have participated in the EU projects.

There are, however, examples of good practice, including:

- introduction of CNC technology in small and medium workshops;
- use of software solutions for 3D modeling, simulation and optimization of production processes;
- partnerships with technical faculties and research centers in order to test and develop new digital solutions.

Identified key barriers to digitization include:

- high costs of initial investments in new equipment and software solutions;
- lack of qualified professional staff for management and maintenance of smart technologies;
- weak intersectoral connection between industry, education, research and the public sector;
- inadequate access to funds for innovation and technical improvement of production capacities.

An additional challenge is the lack of a centralized knowledge and mentoring base that would serve as support for small firms in the process of transitioning to Industry 4.0, as well as the underdeveloped business networks for the exchange of experiences and technology transfer. In order to enable an efficient transition to Industry 4.0, the following measures are needed:

– development and implementation of the national strategy of digital transformation of the industry, which will be harmonized with European standards and best practices;

– institutional support for the establishment and strengthening of innovation clusters, industrial associations and technology parks that bring together companies, academic institutions and startups with the aim of joint development and implementation of technologies;

– creation of favorable financial instruments (grants, tax incentives, digitization vouchers) to enable SMEs to invest in modernization and employee training;

– construction of regional centers for digital competences and staff education for working with modern technologies within industry;

– launching public campaigns and promotional activities that will raise the awareness of entrepreneurs about the benefits of digitization and innovation;

– active inclusion of digital transformation in all sectoral development policies, with clearly defined goals, indicators and responsibilities of competent institutions.

Digitization must not be seen as a luxury but as a necessity to ensure the competitiveness of the Montenegrin industry. Only with the coordinated action of all actors it is possible to create conditions in which domestic companies will be able to respond to the challenges of the modern market, achieve stable growth and create quality jobs.

6. OPPORTUNITIES FOR INNOVATION AND PARTNERSHIPS

Despite numerous challenges, metal sector of Montenegro has significant development potential that can be activated through strategic investments in innovation, research and intersectoral cooperation. This sector has the capacity to become a generator of technological progress and export growth, especially through integration with related industries - such as energy, construction, shipbuilding and the automotive industry.

One of the key development opportunities is reflected in the inclusion of metal companies in international projects and networks, such as Interreg, Horizon Europe and EIT Manufacturing, which provide access to financing, knowledge and technological partners from the EU. Through such initiatives, domestic companies can develop innovative products and processes, improve work organization and strengthen their position in the international market.

The formation and strengthening of industrial clusters, which bring together companies, educational and research institutions, is crucial for knowledge transfer, joint projects and stronger integration into regional value chains. These clusters can become the foundation for development of specialized industrial zones, centers of excellence and regional innovation platforms.

Furthermore, a significant opportunity lies in developing centers for professional training and innovation, through partnerships of technical schools, faculties, business and the public sector. Such centers would enable rapid training of personnel for the specific needs of the industry and at the same time support research and development activities.

Also, connecting with the IT sector and the startup community can accelerate digital transformation through joint projects in the field of software solutions, smart manufacturing and data management. The introduction of the concept of "living labs", in which companies would test new solutions in real conditions, represents an additional chance for the accelerated development of innovations.

Given the climate challenges and the growing importance of the circular economy, the metal sector has the opportunity to develop sustainable solutions, including metal recycling, the production of energy-efficient components and the reduction of CO_2 emissions. Such initiatives can be supported through green investment funds and international climate mechanisms.

7. RECOMMENDATIONS FOR FURTHER STEPS

Based on the analysis of the situation, challenges and potential, the following key recommendations are proposed for strengthening the metal sector of Montenegro, in accordance with the goals of the METATECH4.0 project:

- Create a national strategy for the digital transformation of the industry, with a focus on SMEs and the metal sector.
- Increase financial support for production companies, through equal and transparent programs, available to small and medium-sized companies.
- Establish regional centers for professional training, which will provide continuous education in accordance with the needs of the economy.
- Create a stimulating regulatory framework for innovation, research and development within the industry, with easier access to funds and tax incentives.
- Develop databases for the needs of the labor market, which will serve for planning educational policies and defining enrollment quotas.
- Support the development and networking of industrial clusters, as a basis for cooperation, innovation and joint export.
- Promote technical occupations among young people, through campaigns, career fairs, mentoring and the presence of industry in schools.
- Strengthen cooperation with international partners, through active participation in EU programs and regional initiatives.
- Improve the coordination of educational institutions and employers, through joint definition of competencies, programs and performance evaluation.

The implementation of these measures must be based on intersectoral cooperation, followed by concrete indicators of success and regular evaluations. Only the coordinated action of all actors - state institutions, educational system, economy and international partners - can ensure sustainable and competitive development of the metal sector of Montenegro.

8. CONCLUSION

Based on the data obtained and the initial meeting with potential stakeholders from the database of key companies operating in the field of metal processing, Montenegrin Employers Federation mapped companies and educational institutions in the VET system that offer programs in the aforementioned and other related areas, especially in the field of mechanical engineering.

Accordingly, in the continuation of the project implementation, bilateral meetings of the Montenegrin Employers Federation will be organized with a minimum of five stakeholders, including two educational institutions, two employer entities, and one representative trade union organization with which memorandums of cooperation will be signed.

Some of the recommended digital tools that would be significant for Montenegro in the context of supporting industry and education, and that relate to companies, may be tools such as:

- ERP systems for small businesses (e.g. Odoo, Zoho ERP) – for digitalizing inventory, production and human resources management processes.
- CNC simulators and CAD/CAM software (e.g. Autodesk Fusion 360, SolidWorks) – for technical staff and operators.
- IoT tools for monitoring production processes and basic failure prediction (e.g. ThingSpeak, Siemens MindSphere).

On the other hand, for schools and trainers, the following may be important:

- Digital learning platforms (e.g. Moodle, Edmodo) – for organizing courses and e-learning.
- Virtual laboratories and 3D simulations (e.g. Labster, Festo LX) – for practical exercises in machining, electrical engineering and automation.
- Tools for creating microqualifications and digital badges (e.g. Credly, Badgr) – for verifying acquired skills for students and adult learners.

Mapping the actors of the metal industry and educational institutions is a key step towards establishing sustainable cooperation between the economy and education. Connecting with modern IT tools will further strengthen the capacities of companies and teachers, thereby accelerating the transition to Industry 4.0 in Montenegro. In the next step, based on the mapping, a short report will be prepared with an analysis of needs, potentials and proposals

for digital transformation, as well as proposed models of cooperation and work-based learning.

MetaTech Exchange

BRIDGING INDUSTRY 4.0 IN WESTERN BALKANS

Co-funded by
the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them